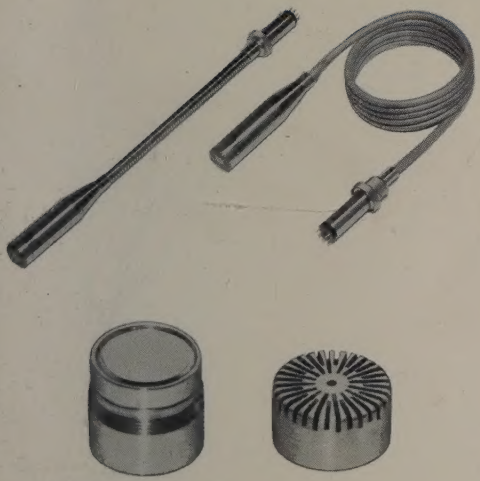
4131/32

Instructions and Applications



One-inch Condenser Microphones

Microphone Cartridges Type 4131/32
Cathode Followers Type 2612/13, 2630
Accessories

Precision condenser microphones for measurement purpose. Each microphone is individually calibrated. Frequency range of calibration 20–20ooo Hz. The 4132 fulfils the requirements of the American Standard A.S.A. Z. 24.8-1949.

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One-inch

Condenser Microphones

Reprint July 1968

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0. Introduction

Purpose of the "One-inch" Condenser Microphones.

The B & K One-inch Condenser Microphones are designed for precision sound pressure measurements. Their range of application covers the whole of the audible frequencies (20 Hz to 18 kHz*) and of pressure levels (15 dB to 146 dB). Their most outstanding feature is excellent long-term stability under a great range of environmental conditions and especially their insensitivity to temperature variations. They are therefore well suited for field measurements, though the accuracy of calibration matches laboratory standard requirements.

The One-inch microphones are of the omnidirective type, with a relatively high sensitivity. They are not designed for permanent exposure outside unless special precautions are taken.

An extensive series of accessories herein described provides a great measuring versatility.

Principle of the Condenser Microphone.

A condenser microphone consists essentially of a thin metallic diaphragm mounted in close proximity to a rigid back plate. Diaphragm and back plate are electrically insulated from each other and constitute the electrodes of a capacitor. See Fig. 0.1. Housing and insulator form with the diaphragm

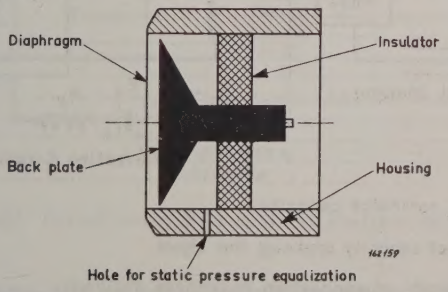
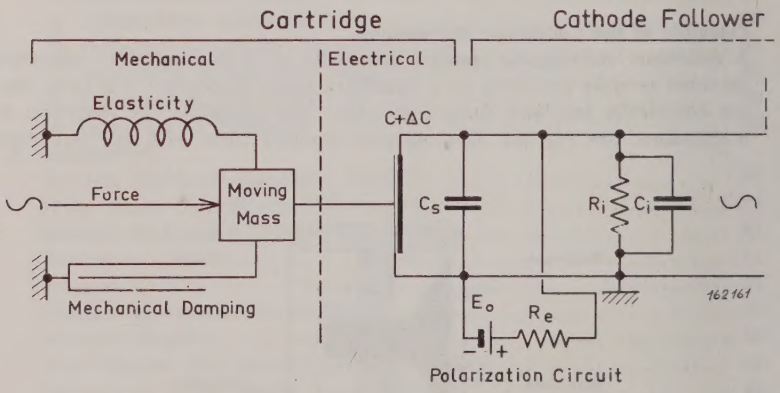


Fig. 0.1. Schematic construction of a condenser microphone cartridge.

*) Hz International.
c/s Used in United Kingdom and U.S.A.

a closed chamber, which is only in communication with the outside for slow static ambient pressure variations. When the microphone is exposed to a sound pressure, the diaphragm is submitted to an alternating force proportional to the pressure and the diaphragm area. The consequent movement of the diaphragm varies the capacity, and these variations are transduced into an AC voltage component if a constant charge is present between the electrodes. The charge is obtained by means of a stabilized DC polarization voltage, and it remains constant as long as the charging time constant of the circuit is much longer than the period of the sound pressure variations. It is possible by careful design to maintain the proportionality of the AC output voltage to the sound pressure within a wide frequency range and an extended dynamic range. The widest linear frequency range for the pressure response is obtained if the resonance of the mechanical system (diaphragm) is critically damped. This damping, which is due to the back and forth movement of the air contained between diaphragm and back plate, is determined by the shape of the back plate and the mechanical tension of the diaphragm.

The low frequency limit of the linear range is set by the "cut-off" (or time constant) of the microphone cartridge circuit. Referring to the schematic



C = Polarized cartridge capacity

ΔC = Variation of capacity producing the signal

C_s = Stray capacity of connection to cathode follower

$R_i C_i$ = Input impedance of cathode follower

Fig. 0.2. Simplified diagram of the Condenser Microphone. (The electrical leakage in the cartridge is neglected).

diagram of Fig. 0.2 the cut-off frequency is equal to:

$$\frac{1}{2\pi\,(C + C_s + C_i)\,\dfrac{R_i\,R_e}{R_i + R_e}}$$

Since the sensitivity of the microphone is determined by the relative variation of capacity $\Delta C/(C + C_s + C_i)$, the total parallel capacity should be made as small as possible. The first amplifier stage is therefore built in the same housing as the microphone. A cathode follower stage giving high R_i is employed, because the small parallel capacity requires high R_i and R_e in order to obtain a satisfactory low limiting frequency.*)

Definitions of Free-field and Pressure Response.

The *Free-Field Response* of a microphone is the ratio of the RMS output voltage to the RMS sound pressure existing in a free field (plane sound waves) at the microphone location with the microphone removed.

The *Pressure Response* of a microphone is the ratio of the RMS output voltage to the RMS sound pressure, uniformly applied over the diaphragm.

The two definitions coincide for a microphone having negligible dimensions with respect to the sound wavelength. In the case of the B&K one-inch microphones this is practically fulfilled up to about 1400 Hz, where the wavelength is equal to ten times the diameter of the microphone (i.e. 240 mm). The difference in response is then a small fraction of a decibel.**)

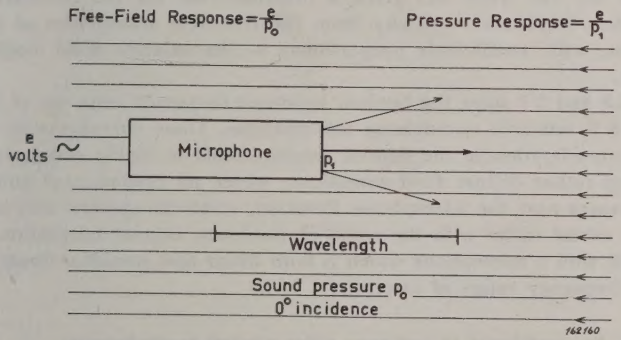


Fig. 0.3. Definitions of Free-field and Pressure Response.

*) It should be noted, however, that with the circuitry employed in the cathode follower herein described (Type 2612/13) the low-frequency cut-off law may deviate somewhat from a simple R-C law.

**) In the particular case of the 90° incidence (parallel to diaphragm) the difference in response remains negligible up to 10 kHz. See Fig. 1.14.

At higher frequencies the diffractions of the sound waves on the microphone produce an appreciable change in the resulting sound pressure acting on the microphone diaphragms as illustrated on Fig. 0.3. The difference $p_1 - p_0$, called *free-field correction,* depends on the orientation of the microphone with respect to the direction of propagation of the sound and on the external dimensions of the microphone (in particular those of the front and of fitted protective grids or "nose cones").
The free-field behaviour of a microphone is thus described by means of a set of free-field correction curves for various incidences, which have been measured on a model of the microphone (see B&K Technical Review Nos. 1 & 2-1959), and which should be added to the pressure frequency curve of the microphone in each particular case. See Fig. 1.16—1.19.
For microphones intended for free-field work it is possible to give the diaphragm resonance such a damping that the normal incidence free-field corrections are compensated for up to frequencies well above the resonance frequency, in order to obtain the flattest possible frequency response.

Random Incidence Response (Diffuse Field Response).
The random incidence response of a microphone for a given frequency is the root-mean-square value of the free field sensitivity for all angles of incidence of the sound wave. It corresponds to the diffuse field sensitivity of the microphone, the diffuse field being a sound field in which the sound energy density is uniform and the mean acoustic power per unit area is the same in all directions. The International Electrotechnical Commission (publication no. 123, § 8.2) has given a practical rule for the calculation of the random incidence sensitivity from the free-field sensitivities at definite angles, with coefficients proportional to the relative solid angles. See page 21.
Figs. 1.14, 2.3 and 2.7 show the random incidence frequency response of the different B & K one-inch microphone combinations. These curves should be taken into consideration in the case of measurements in highly reverberant rooms giving rather diffuse field conditions, where no predominant sound source is present near the microphone. However, when the spectral distribution of the sound varies with the angle of incidence, correct integration is only possible with a microphone which is both linear and omnidirectional in the whole frequency range of interest.

Response to be considered in ordinary noise control measurements.
In practice most measurements are carried out in sound fields whose characteristics are in between the definitions of the *free field* corresponding to a perfectly "dead" room or 100 % open space, and of the *diffuse field* corresponding to a perfectly reverberant room.
Consider the common example of sound level measurements in a large typing office at various locations. There the sound field is approximately

free (predominant direction of the acoustic energy flow) near a particular typewriter, and diffuse (if no predominant reflected wave) near the boundaries of the room.

The frequency response of the microphone is thus changing from one position to the other. This change is only important at frequencies above 3 kHz for the one-inch microphones, as seen in Fig. 1.14, but these are especially important in the case of "noiseness" (Noys or PN dB) measurements.

In intermediate positions, it is practically impossible to predict the nature of the field, or which incidences should be considered. A microphone which is omnidirectional at least up to 10 kHz is then obviously advantageous. Then the random incidence response is of course identical to the free-field response which is the same at all incidences. Omnidirectivity is required in the standards for sound level meters (e.g.: IEC 123, § 5.1) but it is rather difficult to achieve without reducing the dimensions and thereby the sensitivity of the microphone. Thorough research carried out by B & K has culminated in the successful design of a specially shaped device which, when mounted in place of the protecting grid on the one-inch microphone, ensures satisfactory omnidirectivity. (Type UA 0055, see Accessories).

Omnidirectional microphones are also necessary in the case of rapidly moving sound sources (aeroplanes, motorcars, etc.).

1. Description

General.

A complete microphone consists of a microphone cartridge and a cathode follower for impedance conversion, allowing long cables and relatively low input impedance amplifiers to be used between the microphone and the measuring instrument. The microphone cartridge is screwed onto the housing of the cathode follower making a small, rugged unit. Fig. 1.1.

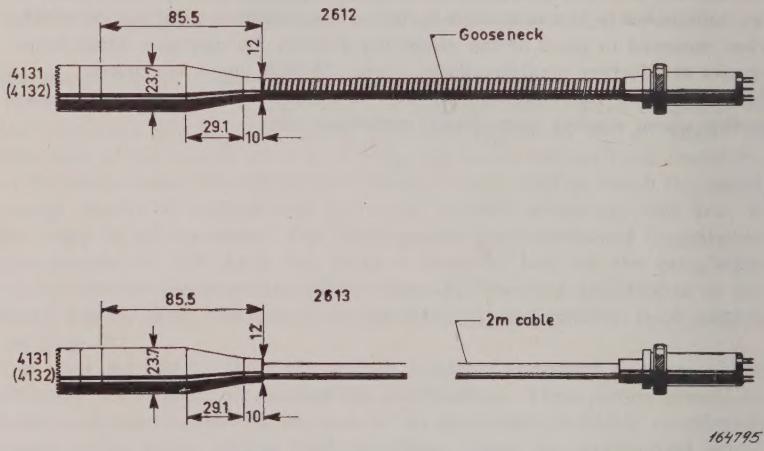


Fig. 1.1. Complete Microphone, consisting of Microphone Cartridge Type 4131 or 4132 and Cathode Follower Type 2612 or 2613.

The microphones may be directly connected to the different B&K measuring instruments which are provided with a CONDENSER MICROPHONE input socket fitting the microphone connecting plug. Stabilized plate and heater voltages for the cathode follower and polarization voltage for the cartridge are available on this seven-pin socket. The microphones may also be used with other equipment when operated from Microphone Power Supplies which provide the necessary voltages in the same conditions as the measuring instruments, or with the Battery-driven Cathode Follower Type 2630 (see Accessories). For free-field and room-acoustic measurements, the microphones should be placed apart from the measuring instruments, since

these would often disturb the sound field because of their non-negligible dimensions. A Microphone Stand and extension cables are available for this purpose, see Accessories. An example of measuring equipment is shown in Fig. 1.2.

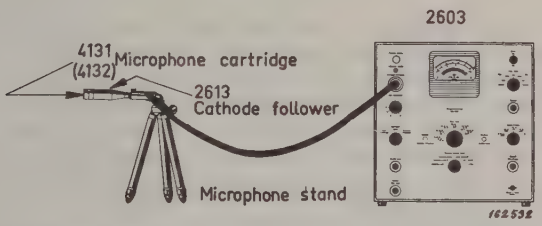


Fig. 1.2. Typical measuring arrangement: one-inch microphone equipped with Cathode Follower Type 2613 connected to a B&K Microphone Amplifier.

Description of the Microphone Cartridges Type 4131 and 4132.

Two slightly different one-inch microphone cartridges are available:

(1) the Microphone Cartridge Type **4131** designed for free-field measurements and featuring a normal incidence free-field frequency characteristic which is flat up to 18 kHz (with protecting grid mounted).

(2) the Microphone Cartridge Type **4132** presenting a pressure frequency characteristic which is flat up to 7 kHz.

The difference in characteristics are summarized in Fig. 1.14.

The two cartridges have basically the same mechanical construction and differ only in the **damping of the diaphragm resonance.** The resonance is overdamped in the case of Type 4131, in such a way that the normal incidence free-field pressure increase is compensated by the decrease of pressure sensitivity up to 18 kHz. In the case of Type 4132 the resonance is approximately

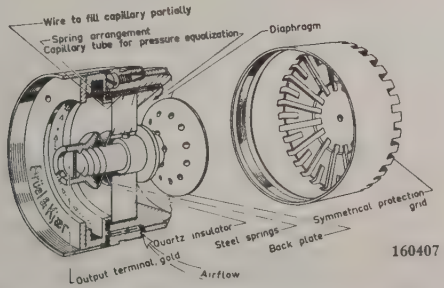


Fig. 1.3. Exploded view of a one-inch microphone cartridge.

critically damped in order to obtain the flattest possible pressure frequency response (Fig. 1.14). The resonance frequency is approximately 10 kHz for the 4131 and 8 kHz for the 4132. The damping is controlled by means of appropriate holes in the back plate and by adjusting the tension of the diaphragm.

Towards the low frequencies the response of the cartridges is only affected by the influence of the **pressure equalizing arrangement.** This arrangement consists of a capillary leakage hole through which the equalization of the static air pressure on both sides of the diaphragm is obtained at a suitable rate. The influence of ambient pressure (or altitude) variations on the microphone sensitivity has been minimized by proper design of the pressure equalization hole. (For adjustment of the pressure equalization see item 10 of General Characteristics).

The equalization hole is situated in front of the grid- and coupler mounting-thread. The pressure equalization is then obtained also in the case of closed cavity measurements. In addition, the temperature inside the microphone is a few degrees higher than the temperature at the equalization opening due to the heat generated by the cathode follower, this prevents moisture condensation taking place inside the cartridge. The time constant of the pressure equalization of Types 4131-4132 is 0.05 second. This corresponds to a — 3 dB cut-off frequency of 3 Hz approximately, and will not influence the measurements, since the — 3 dB low frequency cut-off of the complete microphone is 10 Hz. Microphone cartridges with lower or higher time constants may be obtained from B & K if specified when ordering.

The mechanical construction of the cartridges is shown in Fig. 1.3. The choice of the materials and the design of the mountings of the different parts are made principally with a view to obtain the best possible long-term **stability** and temperature independence of sensitivity. The cartridges are also

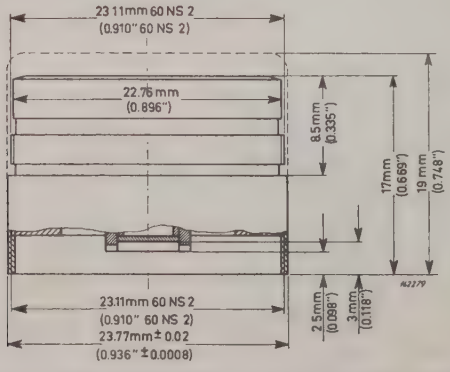


Fig. 1.4. Dimensions of the "one-inch" microphone cartridges Type 4131-4132.

subjected to a complete artificial aging process during manufacture. The basic parts are made of high nickel alloy (K-Monel). The insulator used is silicone treated quartz and for guaranteeing a disturbance-free connection to the cathode follower, gold-plated contacts are used.
The diaphragm is made of a 5 μ thick nickel plate and is mounted at a distance of 22 μ from the back plate. This distance is reduced to 20 μ when the 200 V polarization voltage is applied. The **polarized cartridge capacity,** which is of the order of 60 pF, is measured individually for each cartridge (see the calibration chart). The insulation is verified as higher than 10^5 MΩ.

Silica Gel Cap UA 0135.
This device, supplied with all B & K microphone cartridges will allow the microphones to be stored in a hot, high humidity atmosphere without running the risk of condensation occuring inside the microphone cartridge when taken into a cooler atmosphere for use. It will also serve as an effective dust cover.

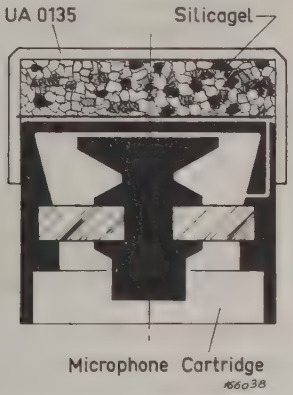


Fig. 1.5. The Silica Gel Cap UA 0135 mounted on a 1" Microphone Cartridge.

The cap is made of a high temperature resistant material and filled with an indicator type moisture absorbent (Fig. 1.5). In this dry condition this absorbent is *blue* but when its colour becomes *pink* then the absorbent is saturated with water and should be restored to its dry condition by heating. This "drying out" process can be carried out repeatedly, simply by heating the absorbent in an oven for 1/2 — 1 hour at a temperature from 100°C (212°F) to 150°C (300°F).
When the microphone is stored, the absorbent is only exposed to the air within the microphone cartridge. To continue this protection against unnecessary saturation when the microphone is in use, the cap should be placed in the upper part of the cartridge hole in the microphone box, which will

Fig. 1.6. The Silica Gel Cap UA 0135 placed in the cartridge hole in the microphone box.

seal against the rim of the cap (Fig. 1.6). From the dry to saturated condition, the cap will absorb approximately 0.17 mg of water.
1″ microphone cartridges have an internal volume of 1 cm^3, and the total air volume enclosed under the cap when mounted on a cartridge is approximately 2 cm^3. The water content of saturated air is:

9.4×10^{-6} gram/cm^3 at 10°C
17.3×10^{-6} gram/cm^3 at 20°C
30.4×10^{-6} gram/cm^3 at 30°C
51.1×10^{-6} gram/cm^3 at 40°C.

Cleansing of the Microphone Diaphragm.
CAUTION. On no account should the diaphragm which is only 5 μ (0.0002″) thick come into contact with fingers or other objects. The protecting grid should only be removed when absolutely necessary. This grid is an effective protection against mechanical damage but cannot stop liquids or dust from falling on the diaphragm. Should the diaphragm become contaminated it may be dried off with cotton-wool or a very soft paint-brush, using great care, and if necessary a proper solvent. The diaphragm will not normally corrode, but any appreciable added mass will change the frequency response.

Description of the Cathode Followers Type 2612 and 2613*).

The Cathode Followers Type 2612 and 2613 are designed for connection to the B & K Condenser Microphone Cartridges or Accelerometers, transforming the high source impedance of the transducer to a 750 Ω output impedance.

*) The cathode-follower Type 2630 is described in "Accessories".

They are electrically identical units. The mechanical construction, however, is different in that the Cathode Follower Type 2612 is fitted to a flexible goose-neck, while Type 2613 is supplied with a 2 m long multi-core cable as shown in Fig. 1.9.

The outside diameter of the cathode followers is identical to that of the microphone cartridges, i.e. 23.77 mm (0.936"), over a length of 48.4 mm.

To ensure high operating stability under conditions of large temperature changes and external vibration, the components used have been carefully selected and are mounted on glass laminated boards. Use has been made of silver plated printed circuitry and the amplifier tube chosen meets the Mil-EIC specifications. The complete component assembly is silicone treated which provides a high resistance to moisture. In the interests of good electrical connection and low noise the contact between cathode follower and microphone cartridge is made through gold.

The influence of vibrations is described in Figs. 1.32 and 1.33.

Before mounting each tube is tested for sensitivity to shock and during the final tests the cathode followers are exposed to a sound pressure of 130 dB where the microphonics is measured at all frequencies from 20 to 20000 Hz. The signal-microphonics ratio is greater than 50 dB with reference

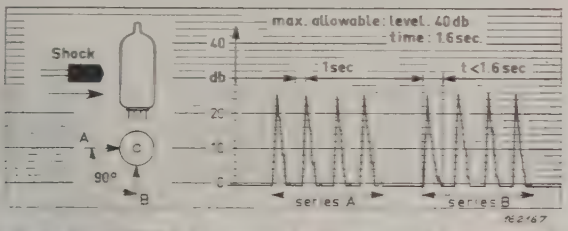


Fig. 1.7 Test of a tube EF731. Microphonics are excited by means of two series of lateral shocks and recorded whereby the amplitude and duration of transients are closely checked.

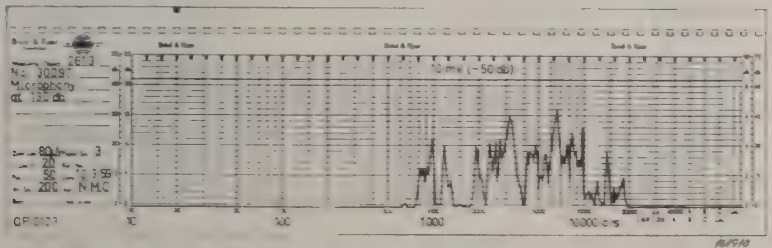


Fig. 1.8. Recording of the output from a Cathode Follower with a dummy microphone of 60 pF when exposed to a sound field of 130 dB in the frequency range from 20 to 20000 Hz. The output signal is at any frequency more than 50 dB below that obtained with the microphone cartridge in place.

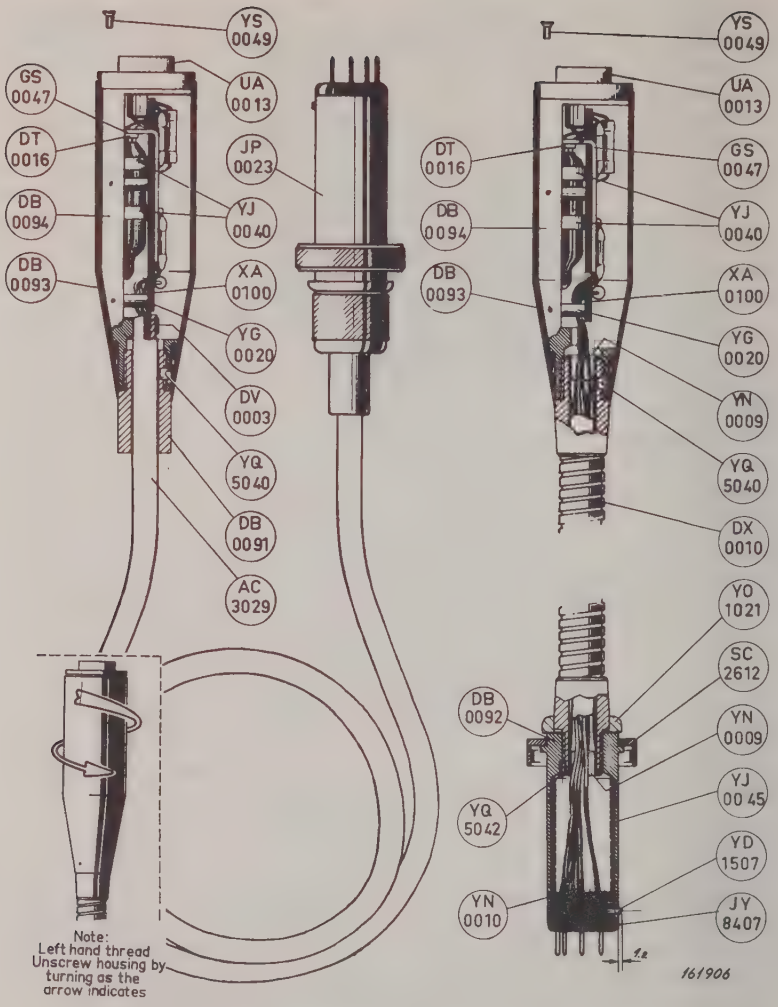


Fig. 1.9. Cathode Followers 2612—2613 with Part Numbers.

to a microphone with a sensitivity of 5 mV/μbar. See Fig. 1.8. The input is internally shielded by means of a "guard ring" which is connected to the cathode of the tube. In this way the input capacity is reduced to an absolute minimum. See Fig. 1.10. By extending the internal shield it is possible to use

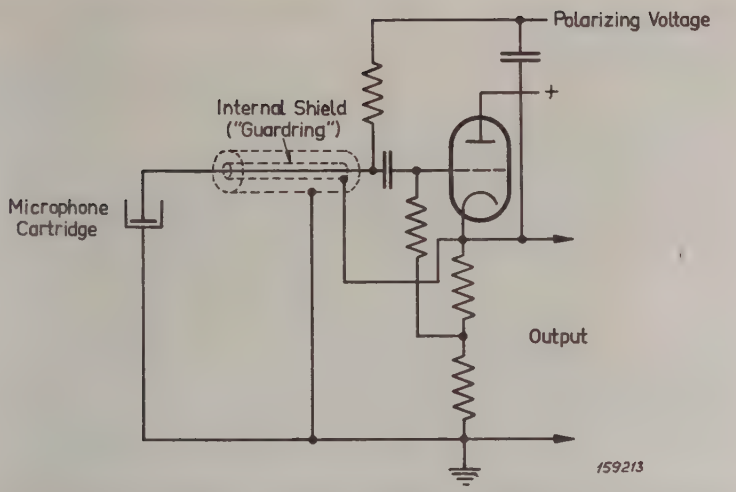


Fig. 1.10. Basic diagram of a cathode follower showing the principle of the "guard ring" system.

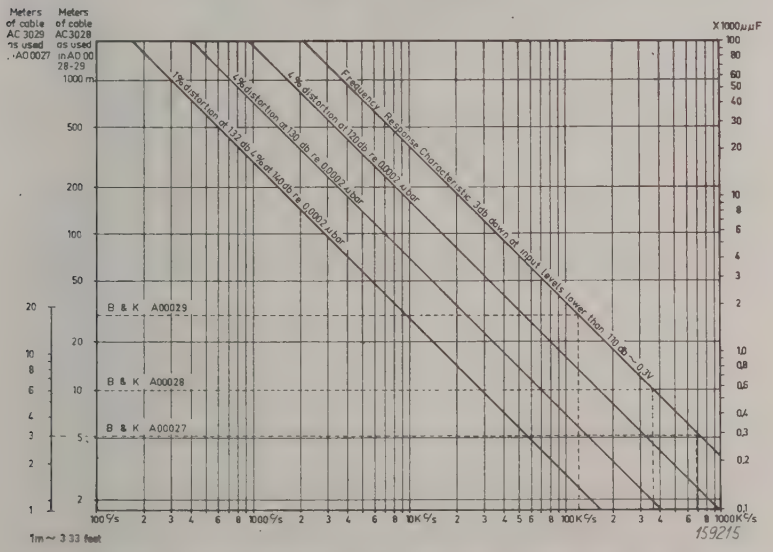


Fig. 1.11. Graph of cathode follower high frequency performance with different lengths of connecting cable attached to the output. To illustrate the use of the graph the standard B & K microphone cables are drawn in. The cables AC 3028 and AC 3029 are the types of cable used by B & K, but without connecting plugs and sockets in the ends.

the microphone cartridge at some distance from the cathode follower. See Accessories: Extension Rod UA 0039.

The Cathode Follower Type 2612 can be mounted either directly on one of the B & K Microphone Amplifiers or Frequency Analyzers, or connected via a seven-conductor extension cable. When used with an extension cable it can be mounted on a B & K microphone stand.

The total capacity of the extension cables will, to a certain extent, load the cathode follower and lower the high frequency cut-off point which will produce distortion at high sound pressure levels. At normal levels, this will only be of importance when very long cables are used, but this does not infer any serious limitation in the practical use of the microphones. The relationship between high frequency cut-off, cable length and harmonic distortion are given showing the limiting values in Fig. 1.11.

Type 2613 is intended for direct mounting on a B & K Microphone Stand and may also be suspended by means of its own cable.

The power supplies necessary to operate the cathode followers are provided by the B & K amplifiers via the multi-socket at the front panel (Fig. 1.12) or by Microphone Power Supplies Type 2801 and 2803 (see Accessories).

SPECIFICATIONS:

Input Impedance: 270 MΩ in parallel with 3 pF.

Output Impedance: 750 Ω.

Transmission Loss: Voltage loss: o.8 dB ± o.2 dB.

Self-generated Noise Level: Approx. 20 μV with the input loaded by a capacitor of 60 pF. (20 Hz—20 kHz).

Maximum Input Voltage for 4 % Distortion: 20 volts RMS (with load impedance > 50 kΩ).

Tube: EF 731 (5899), specially tested for low microphonics.

Accessory included: Input Adapter JJ 2612 fitting the B & K coaxial plugs, for direct connection of accelerometers etc. instead of a microphone cartridge.

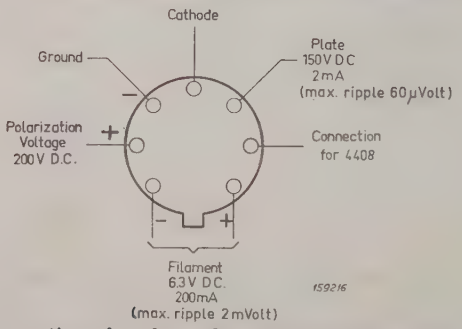


Fig. 1.12. Plug connections for the cathode followers (viewed from outside).

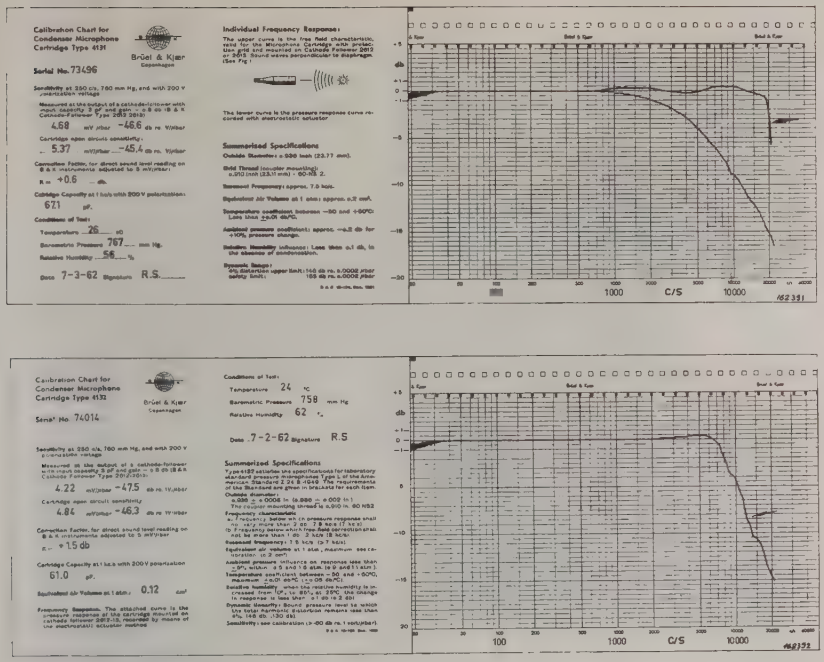


Fig. 1.13. Typical calibration chart as supplied with the microphone cartridges. The automatic plotting process used in production has an accuracy of 0.2 dB up to 10 kHz and 0.5 dB up to 20 kHz.

(Contains a series capacitor of a few thousand pF for blocking the 200 volts polarization voltage).

General Characteristics (Cartridges + Cathode Followers).

1. Sensitivity.

The sensitivity of both cartridges measured at the output of the associated cathode followers are within the limits 3.5—6 mV/μbar. Each cartridge is, however, individually calibrated and supplied with its specific calibration chart when delivered, see Fig. 1.13.

The calibration is carried out at 250 Hz and with a cathode follower presenting the exact nominal characteristics: gain 0.8 dB and input capacity 3 pF (see the technical data for the cathode followers).

The open circuit sensitivity, which is calculated from the overall sensitivity, is also indicated on the calibration chart together with the polarized cartridge capacity. When this capacity is exactly 60 pF the open circuit sensitivity is 1.2 dB higher than the overall sensitivity measured at the output of the reference cathode follower.

2. Frequency Response.

Each microphone cartridge is provided with an individual frequency response determined by the electrostatic actuator method (Fig. 1.13) giving pressure conditions. The free-field response at a particular incidence is obtained by adding to this pressure response the relative free-field correction given in

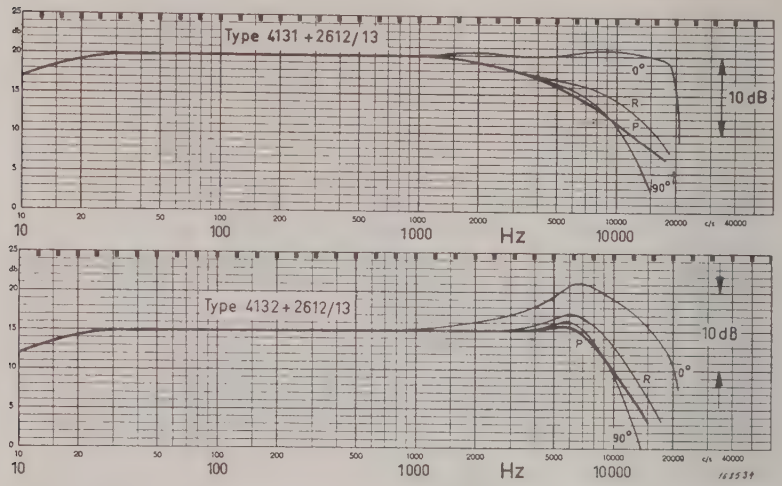


Fig. 1.14. Typical frequency characteristics of the one-inch microphones with protecting grid.

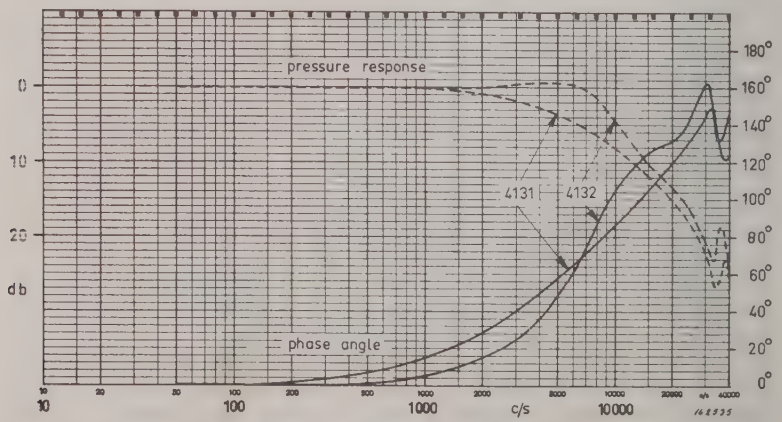


Fig. 1.15. Typical pressure-response phase angle characteristics of the microphone cartridges. Below 50 Hz, the phase shift becomes slightly negative because of the cathode follower.

item 4. This is done on the individual chart of the 4131 cartridges for the 0° incidence (with grid) since the flatness within ± 2 dB of this characteristic is the basis of the adjustment of the pressure response (Fig. 1.13). In Fig. 1.14, the two extreme cases 0° and 90° incidence, and the random incidence (diffuse field) characteristics, have been represented for comparison purposes in a typical case. Characteristics at other angles of incidence may be deduced from the particular pressure response and the curves of Figs. 1.16 and 1.17. It should be noted that when reciprocity calibration is carried out according to the proposed ASA Standard for calibration of microphones (revision of Z 24.9-1949 and Z 24.11-1954) the pressure response should be determined with the microphone diaphragm loaded by a very high acoustic impedance. This is not the case when the pressure response is determined by the electrostatic actuator method and the free field correction curves are therefore not the same.

Figs. 1.18, 1.19 and Table I give the free field corrections to be added to the pressure characteristic when this is determined by the ASA method.

3. Phase Characteristics.

The pressure response phase angle characteristics for the complete micro-

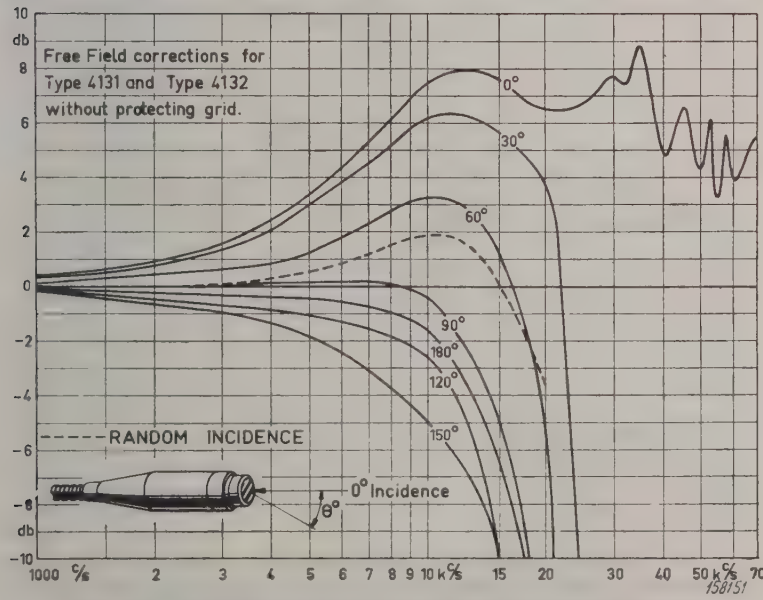


Fig. 1.16. Free field correction curves to be added to the pressure characteristic of the microphones when used without the protecting grid. (The pressure characteristic is determined by the electrostatic actuator method).

phones, that is the cartridge and a cathode follower, can be seen in Fig. 1.15. The diaphragm resonance (90° phase angle), which is approximately critically damped, occurs at about 10 kHz for Type 4131 and 8 kHz for Type 4132.
Fig. A.9 of the Appendix shows some examples of pulse responses.
It should be noted that for positive polarizing voltage as used in normal B & K cathode followers and preamplifiers, the output signal will be negative for positive pressure on the diaphragm. For other systems look in the instruction manual for information regarding this point.

4. Free-field corrections and Directional Patterns.
The pressure increase which is caused by the reflections of free-field sound

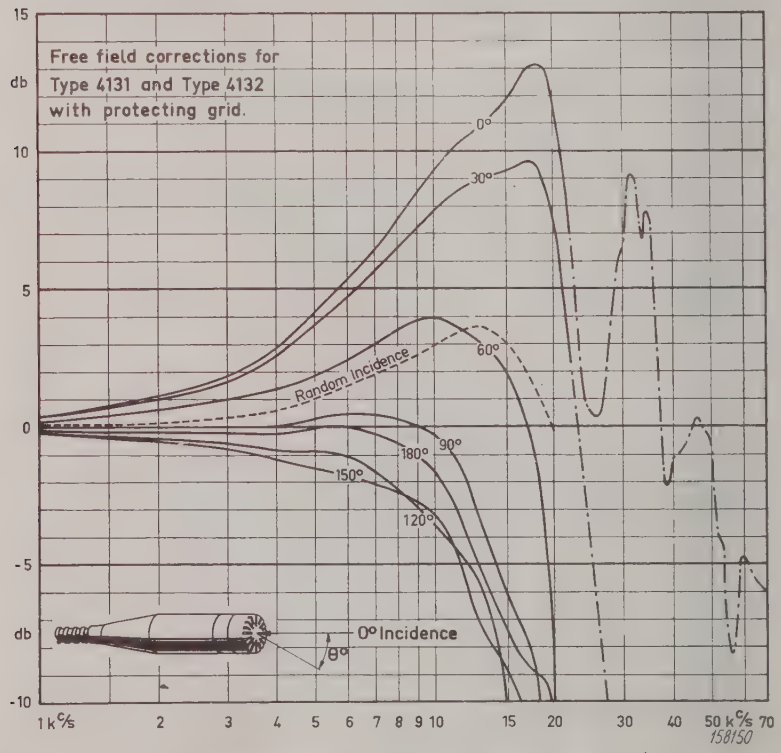


Fig. 1.17. Same as Fig. 1.16 but with the protecting grid.
All "one-inch" grids are adjusted in order to be acoustically identical within ± 0.2 dB up to 15 kHz and ± 0.5 dB above.
A comparison between Fig. 1.16 and 1.17 shows that the microphone should be used without grid when measurements are intended above 18 kHz.

waves on the microphone diaphragm becomes appreciable above 1 kHz. The corresponding correction curves, which are valid for both cartridges are given in Figs. 1.16 and 1.17.

When mounting a Random Incidence Corrector or a Nose Cone on the microphones, however, the free-field corrections are practically independent of the incidence. This is of great interest when using the microphones in complex sound fields (indoors). See Accessories. The random corrections are calculated according to the recommendations of the IEC for Sound Level Meters: (S = random incidence sensitivity). IEC 123 § 8.2.

$$S^2 = 0.018 \times S^2_0 + 0.129 \times S^2_{30} + 0.224 \times S^2_{60} + 0.258 \times S^2_{90} + 0.224 \times S^2_{120} + 0.129 \times S^2_{150} + 0.018 \times S^2_{180}$$

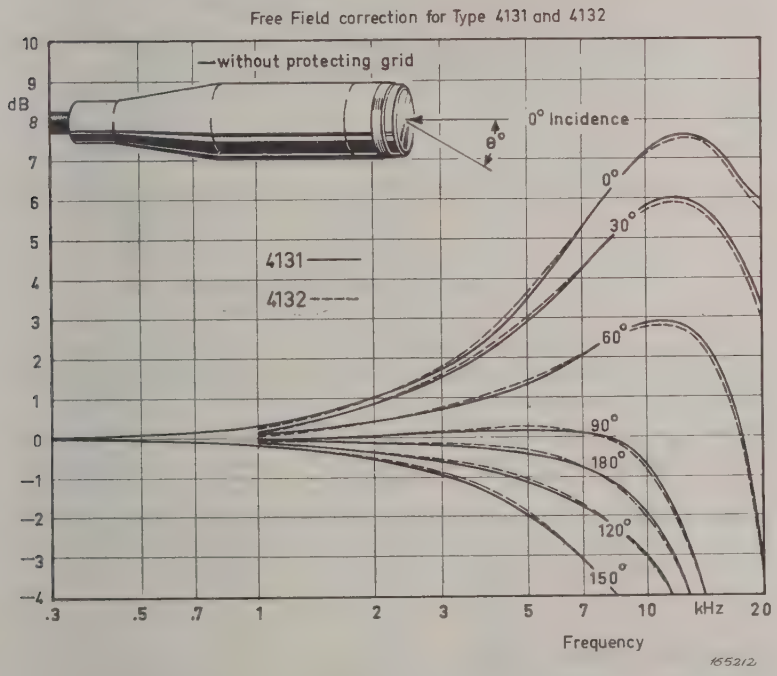


Fig. 1.18. Free field correction curves to be added to the pressure characteristic of the microphones when used without the protecting grid. (The pressure characteristic is determined by the ASA method).

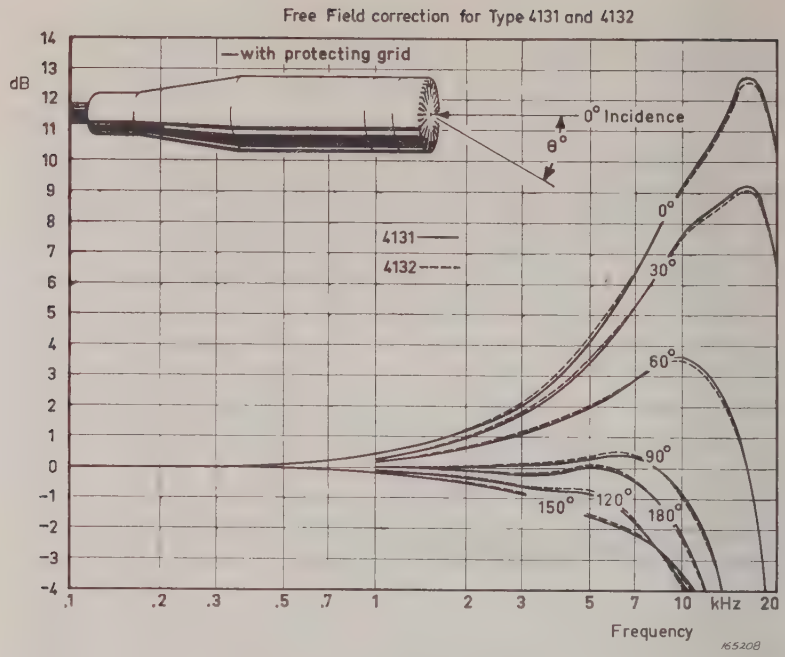


Fig. 1.19. Same as Fig. 1.18 but with the protecting grid.

Figs. 1.18 and 1.19 show the correction curves to be employed when the ASA method is used to determine the pressure characteristic. The corrections are also given in Table I.

As both types of cartridges have the same mechanical dimensions their directional properties are practically identical, Fig. 1.20.

NOTE: *Better omnidirectional properties are obtained if the protecting grid is substituted by a Random Incidence Corrector UA 0055 or a Nose Cone UA 0051 (see Accessories).*

5. Polarized Cartridge Capacity.

Owing to the variation of diaphragm compliance the cartridge capacity is dependent on frequency as shown in Fig. 1.21 in a typical case. For the particular value of a cartridge capacity at 1 kHz, see the individual calibration chart.

Table Ia. Free field response level minus pressure response level for typical condenser microphones. Sound propagation perpendicular to the diaphragm. (See also Figs. 1.18 and 1.19).

Frequency in kHz	Western Electric Co. Type 640AA (or Equivalent) Without Protective Grid	Brüel & Kjær Type 4131 or 4132 (or Equivalent) With Protective Grid		Brüel & Kjær Type 4131 or 4132 (or Equivalent) Without Protective Grid	
		4131	4132	4131	4132
	dB	dB		dB	
.3	0.0	0.0	0.0	0.0	0.0
.5	0.1	0.1	0.1	0.1	0.1
.7	0.1	0.2	0.2	0.1	0.1
1.0	0.2	0.5	0.4	0.3	0.2
1.5	0.5	0.9	0.8	0.7	0.6
2.0	0.9	1.3	1.3	1.0	0.9
2.5	1.5	1.6	1.6	1.4	1.4
3.0	2.2	2.1	2.2	1.7	1.8
4.0	3.5	3.1	3.3	2.6	2.8
5.0	5.0	4.1	4.2	3.5	3.7
6.0	6.5	5.3	5.4	4.5	4.6
6.5	7.3	5.7	5.8	4.9	4.9
7.0	7.9	6.3	6.4	5.3	5.3
7.5	8.4	6.7	6.7	5.6	5.6
8.0	8.8	7.4	7.3	6.0	6.0
9.0	9.3	8.3	8.2	6.7	6.6
10.0	9.5	9.2	9.0	7.2	7.1
11.0	9.5	9.8	9.6	7.4	7.2
12.0	9.3	10.2	10.0	7.5	7.3
13.0	9.0	10.9	10.7	7.6	7.4
14.0	8.7	11.6	11.4	7.5	7.2
15.0	8.4	12.4	12.1	7.3	7.1
16.0	8.1	12.7	12.5	7.0	6.8
17.0	7.8	12.7	12.5	6.7	6.5
18.0	7.5	12.3	12.3	6.3	6.1
19.0	7.2	11.8	11.4	6.0	5.8
20.0	7.0	11.0	10.8	5.9	5.7

Table 1b. Free field response level minus pressure response level for typical condenser microphones. Sound propagation parallel to the diaphragm. (See also Figs. 1.18 and 1.19).

Frequency in kHz	Western Electric Co. Type 640AA (or Equivalent) Without Protective Grid	Brüel & Kjær Type 4131 or 4132 (or Equivalent) With Protective Grid		Brüel & Kjær Type 4131 or 4132 (or Equivalent) Without Protective Grid	
		4131	4132	4131	4132
	dB	dB		dB	
.3	0.0	0.0	0.0	0.0	0.0
.5	0.0	0.0	0.0	0.0	0.0
.7	0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.0	0.0	0.0	0.0
1.5	0.0	0.1	0.0	0.0	0.0
2.0	0.1	0.1	0.1	0.1	0.1
2.5	0.2	0.1	0.1	0.1	0.1
3.0	0.3	0.1	0.2	0.1	0.2
4.0	0.6	0.2	0.4	0.2	0.3
5.0	1.1	0.4	0.6	0.2	0.4
6.0	1.6	0.5	0.6	0.1	0.2
6.5	1.9	0.4	0.5	0.1	0.1
7.0	2.1	0.4	0.3	0.0	— 0.1
7.5	2.1	0.2	0.1	— 0.1	— 0.2
8.0	2.0	0.1	— 0.1	— 0.2	— 0.4
9.0	1.5	— 0.3	— 0.5	— 0.3	— 0.5
10.0	0.6	— 0.3	— 1.1	— 0.8	— 0.9
11.0	—	—	—	—	—
12.0	—	—	—	—	—
13.0	—	—	—	—	—
14.0	—	—	—	—	—
15.0	—	—	—	—	—
16.0	—	—	—	—	—
17.0	—	—	—	—	—
18.0	—	—	—	—	—
19.0	—	—	—	—	—
20.0	—	—	—	—	—

6. Dynamic Range, Noise and Distortion.

The lower limit of the dynamic range is set by the thermal noise level of the cathode follower. With a microphone cartridge the sensitivity of which

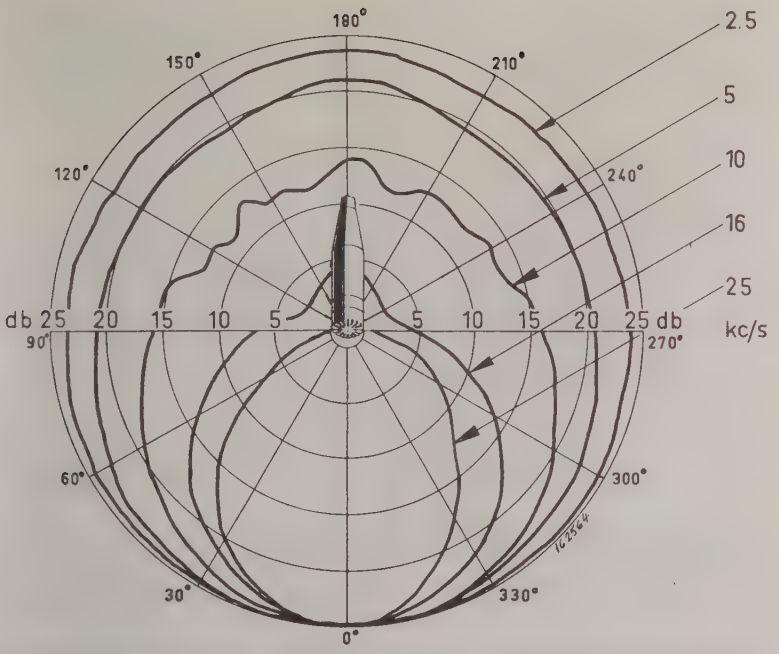


Fig. 1.20. Typical directional characteristics for the 1" microphones with grid.

is 5 mV/μbar this limit will be equal to a sound level of 15 dB with reference to 2×10^{-4} μbar measured with a weighting network curve A. The noise level of the Cathode Followers Type 2612 and 2613 is approximately 20 μV (26 dB with reference to 2×10^{-4} μbar) measured with a capacitor of 60 pF across the input and at a bandwidth of approximately 200 kHz (20 Hz—200 kHz). When measured in ⅓ octave bands the noise level is

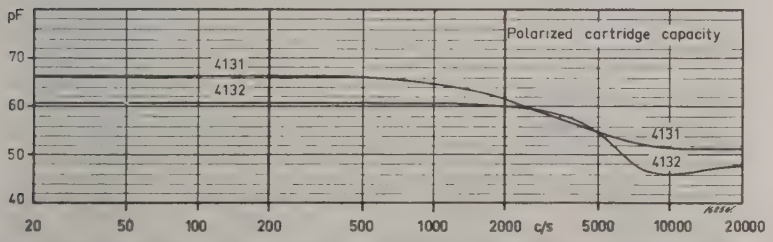


Fig. 1.21. Variation of the electrical capacity of the one-inch cartridges as a function of frequency.

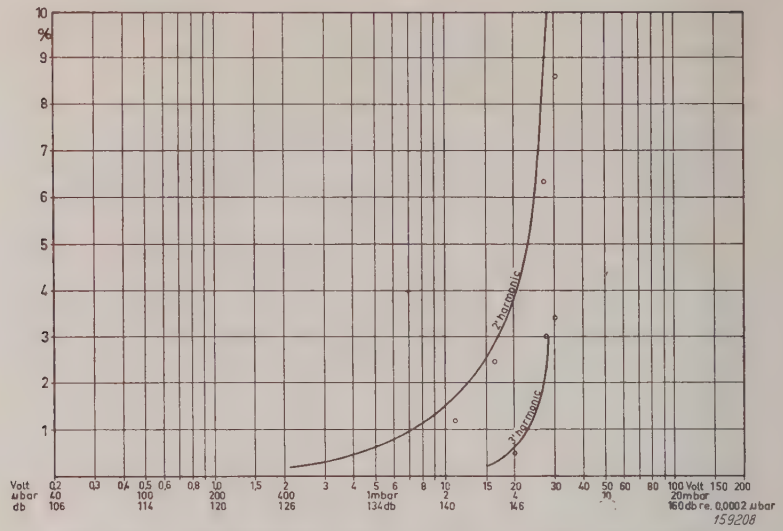


Fig. 1.22. Typical distortion curves for the one-inch microphones. The curves in full are measured on the cathode follower and referred to a complete microphone with a sensitivity of 5 mV/μbar. The measuring points shown are averages measured in a pistonphone on a number of complete microphones at 50 Hz.

less than 2 μV (6 dB with reference to 2×10^{-4} μbar) except at frequencies lower than 120 Hz where it is less than 5 μV (14 dB with reference to 2×10^{-4} μbar).

The upper limit of the dynamic range is set by the harmonic distortion, and is approximately 146 dB for 4 % total harmonic distortion. See Fig. 1.22. No damage will be caused to the cartridge if a sound pressure of up to 165 dB with reference to 2×10^{-4} μbar is used but as this is the highest SPL at which the microphone has been tested it is not recommended to exceed this value. The upper limit is also somewhat dependent on the frequency when long cables are connected to the cathode-follower output, see Fig. 1.11.

7. Influence of the Polarization Voltage.

The condenser microphone cartridges have been designed to operate with a polarization voltage of 200 volts. They are not tested above 260 volts.

The polarization voltage supplied from the instrument to which the condenser microphone is connected should be adjusted to 200 volts before measurements are taken with the 4131 (4132) + 2612 (2613) microphones Adjustment instructions will be found in the respective manuals.

If the Microphone Cartridges Type 4131 and 4132 are operated with polarization voltages differing from the above stated 200 volts their sensitivity as well as frequency characteristics will differ from the nominal values as shown in Fig. 1.23 and 1.24.

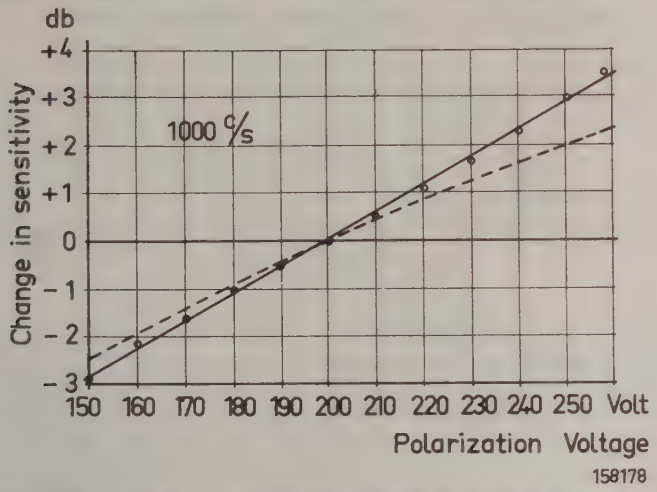


Fig. 1.23. Curve showing the microphone sensitivity vs. polarization voltage at 1000 Hz (fully drawn curve). Dotted curve is calculated without taking the change in air gap into account (simple proportionality).

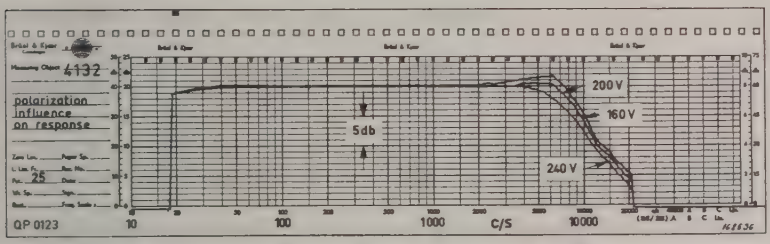


Fig. 1.24. Typical difference in pressure response of the Condenser Microphone Cartridge Type 4132 measured at three different polarization voltages. Recorder adjusted to same deflection at 1000 Hz.

8. Equivalent Air Volume.

At lower frequencies where the motion of the microphone diaphragm is controlled only by stiffness, the acoustical impedance of the microphone is capacitive. In dealing with closed cavity measurements (coupler measure-

ments) in this frequency region it is therefore convenient to express the impedance in terms of an equivalent volume V_a:

$$V_a = \frac{\gamma P}{j \omega Z_a}$$

where γ = ratio of specific heats (1.41). P = ambient pressure and Z_a = acoustical impedance of the microphone. The equivalent volume of the micro-

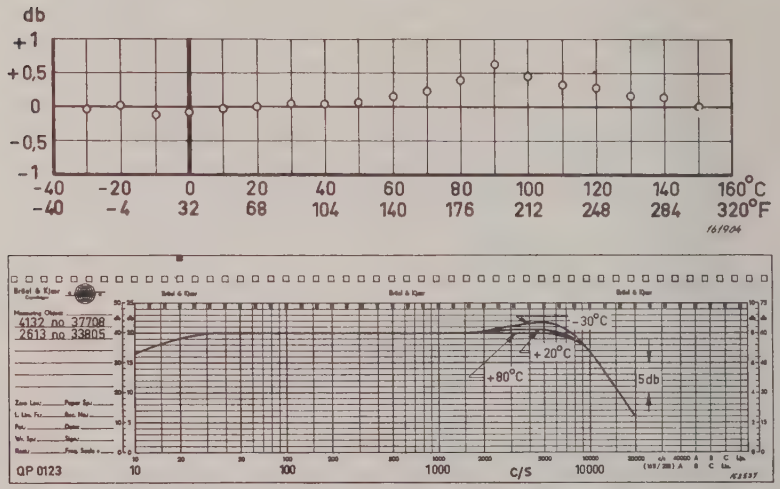


Fig. 1.25. Dependency of microphone sensitivity upon temperature.
a. Sensitivity at 400 Hz.
b. Typical frequency characteristics of Type 4132 at different temperatures.

phone cartridge Type 4132 is less than o.2 cm^3 at 1 atm. It is indicated on the individual calibration chart at 1 kHz. Typical curves of variation vs. frequency are shown in Fig. 1.27.

It should be noted that the equivalent volume specified for the B & K condenser microphones Type 4132 is given in the data sheet enclosed with the complete microphone.

This equivalent volume is stated as being the amount in cm^3 by which the complete microphone, with coupler adaptor ring and diaphragm compliance, is larger than a nominal front cavity of 1.863 cm in diameter and o.1955 cm deep.

This means that no further correction for the coupler volume used is necessary when the equivalent volume specified in the data sheet is used.

Fig. 1.26 shows the method used to measure the equivalent volume. The microphone to be measured is placed on top of the coupler (the position occupied by the dummy on the drawing). The generator is adjusted until the input

voltage on the 1/2″ transmitter condenser microphone cartridge is in phase with the output of the 1/4″ receiver condenser microphone cartridge. Now the microphone under test is replaced by the dummy, and the calibrated center piece of this is adjusted until the in-phase condition between 1/2″ and 1/4″ cartridges is obtained again. The equivalent volume can then be read directly from the scale on the dummy cartridge. Should it be necessary to know the actual compliance of the diaphragm, then the volume of the front cavity can be measured. This is, however, very close to the nominal. The correction for the small slit between the diaphragm rim and the coupler adaptor ring is 0.006 cm^3.

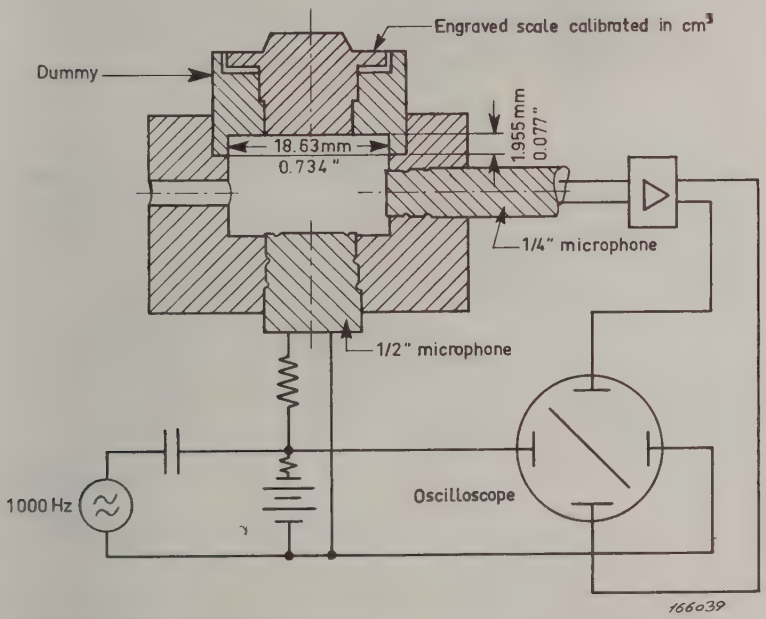


Fig. 1.26. Measuring set-up used to determine the equivalent air volume of the 1″ Condenser Microphone Type 4132.

9. Temperature Characteristics.

Special care has been taken during the development and subsequent manufacture of the microphone cartridges to obtain a calibration characteristic which, to a high degree is independent of temperature, and a typical temperature-sensitivity chart is shown in Fig. 1.25. The cartridges will stand temperatures of up to 200°C in short periods (10 min.). However, the insula-

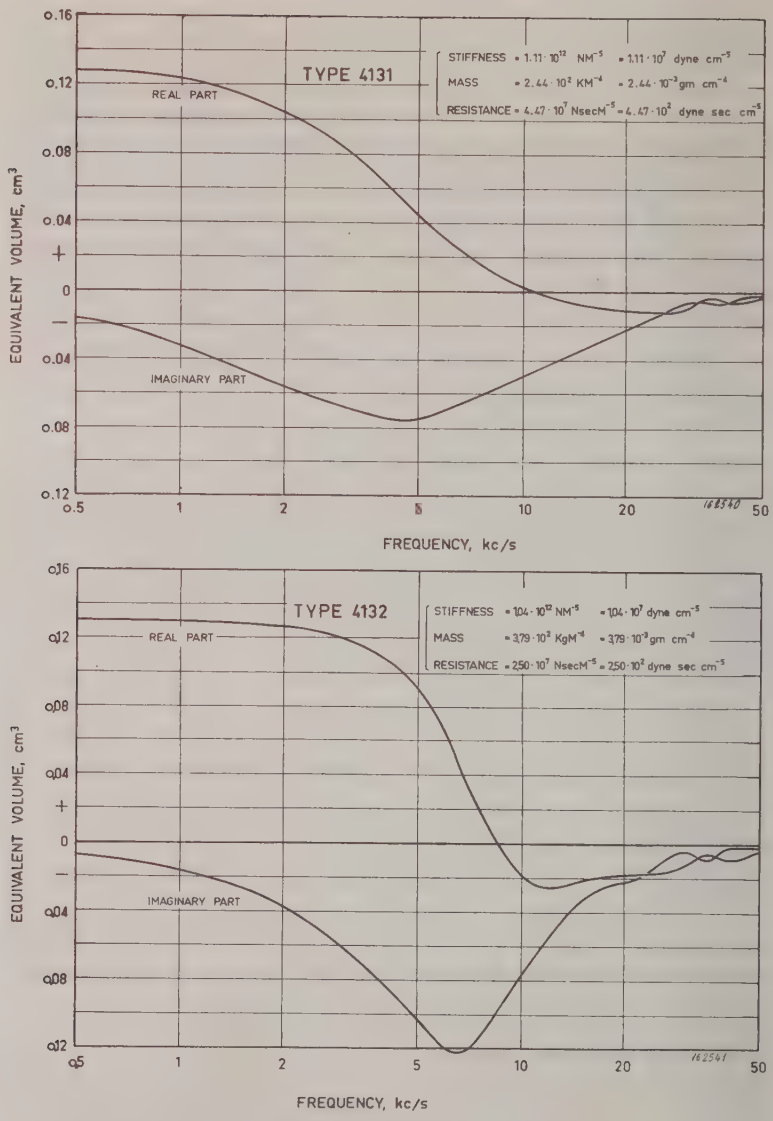


Fig. 1.27. Equivalent Volume and Lumped Acoustical Parameters for the one-inch microphones.

tion material used in the connecting cables of the cathode followers 2612 and 2613 should not be exposed to higher temperatures than 100°C (212°F).

10. Influence of Ambient Pressure.

The microphone sensitivity will vary approximately o.2 dB for o.8 dB variations in ambient pressure.

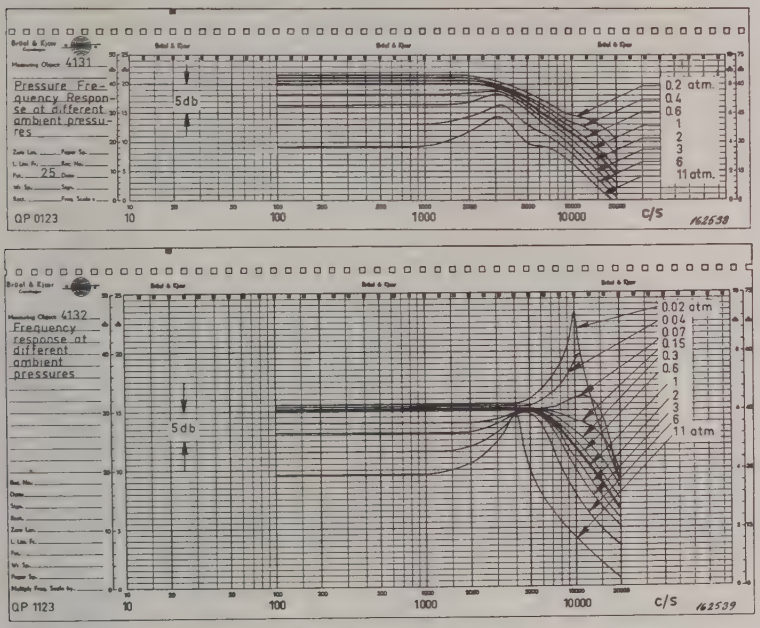


Fig. 1.28. Influence of the static ambient pressure on the frequency response of the one-inch microphones. Below o.1 atm. the characteristics of the 4132 are also valid for the 4131.

Fig. 1.29 shows a curve of the microphone sensitivity at 250 Hz as a function of the ambient static pressure. This curve should be applied with care since the frequency characteristic of the microphone does also change with ambient pressure, see Fig. 1.28.

For a more detailed discussion of the performance under low pressure and varying pressure conditions, see B & K Technical Review No. 1-1960.

Modification of the Pressure Equalization.

When acoustic measurements are to be taken with the microphones 4131, 4132 in places where the ambient pressure is expected to vary rapidly it might be necessary to diminish the time constant of the pressure equalization. To

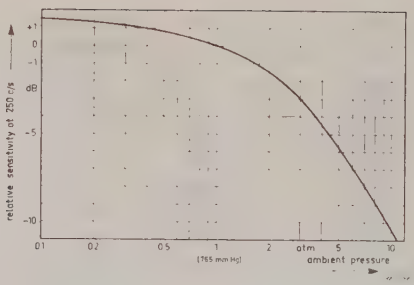


Fig. 1.29. Variation of the one-inch microphone sensitivity at 250 Hz as a function of the static ambient pressure. Measurements made down to 16 mmHg (0.02 atm., or 26 Km — 86000 ft. altitude) show that the sensitivity in vacuum would be around 1.5 dB higher than the sensitivity at 1 atm.

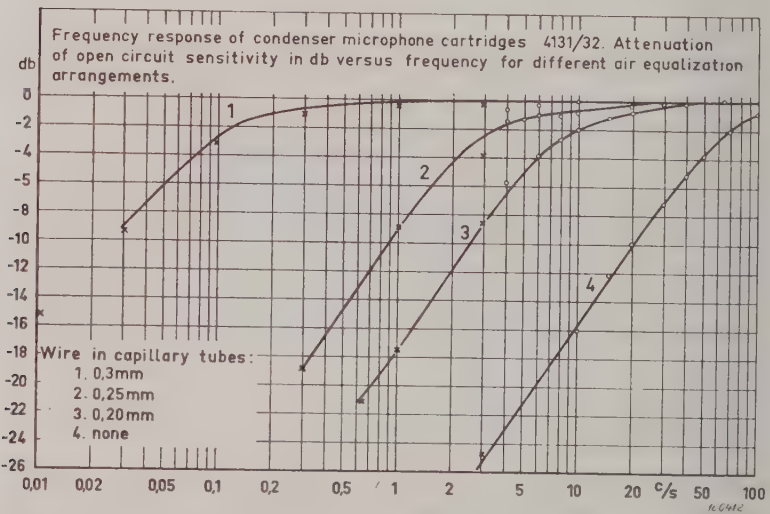


Fig. 1.30. Open circuit low frequency response for the Microphone Cartridges Type 4131 and 4132 (Curve 1 has been determined with a carrier frequency measuring arrangement. See also the B & K Technical Review No. 1, 1960).

do this the tightening rings seen in Fig. 1.3, must be unscrewed and the thin wire in the capillary tube removed or replaced by a thinner wire (Fig. 1.30). The spring arrangement is then remounted and the cartridge is ready for use again. By removing the wire completely the time constant will be approx. 8 msec corresponding to a low frequency cut-off of 50 Hz.

NOTE: During the modification the cartridge should be held vertically with the diaphragm downwards. It is strongly recommended to recalibrate the microphone after this modification has been made. See "Microphone Calibration" in Appendix.

11. Sensitivity to Magnetic Fields.

The sensitivity of the microphone to magnetic fields can be seen from Fig. 1.31. The output signal from the cathode follower was recorded while the microphone + cathode follower was exposed to a magnetic field having a strength of 50 gauss. The sensitivity to a 50 gauss field will thus be approximately 70 dB in terms of equivalent Sound Pressure Level. Although this sensitivity is very low, the influence from magnetic fields may be completely avoided by screening the cartridge + cathode follower with a 2″ diameter iron tube. In the case of Type 2612, the magnetic shielding should also completely cover the goose-neck.

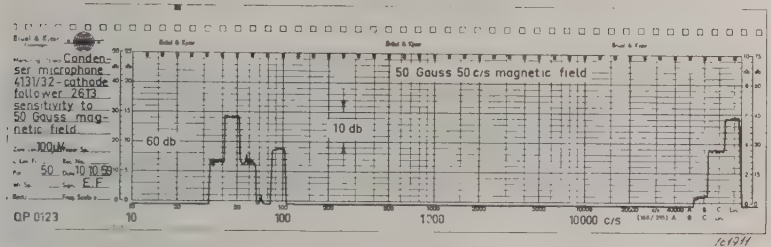


Fig. 1.31. Spectrogram of the output from the cathode follower when the microphone is exposed to a magnetic field of 50 gauss with the most unfavorable orientation.

12. Influence of Vibrations.

The influence of vibrations will depend on the direction in which it is applied to the microphone. When the force is acting in a direction which is parallel to the axis of symmetry (i.e. at right angles to the diaphragm) the sensitivity to vibration is mainly determined by the mass of the diaphragm and the air column on both sides of it. The microphone will be most sensitive to vibration acting in this direction, but due to the low diaphragm mass, the signal produced from vibrations having an acceleration of 1 G is as low as an equivalent sound pressure level of 86 dB. The sensitivity to vibrations acting at right angles to the axis of symmetry (parallel to the diaphragm) is determined by the electrodes of the cathode follower tube.

In Fig. 1.32 is shown a recording of the output signal from a cathode follower with dummy microphone when vibrated at 40 Hz 15 G. Each tube Type 5899 used in the B & K Cathode Followers is individually shock tested in a special jig, where it is exposed to two series of standard hammer blows. Between the two series of blows the tube is turned 90°.

In Fig. 1.33 is shown the sensitivity to vibration of varying frequencies. The sweep covers the frequency range from 10 Hz to 2000 Hz. The slight increase towards the higher frequencies is due to the difficulty in maintaining the correct movements of the shaker table.

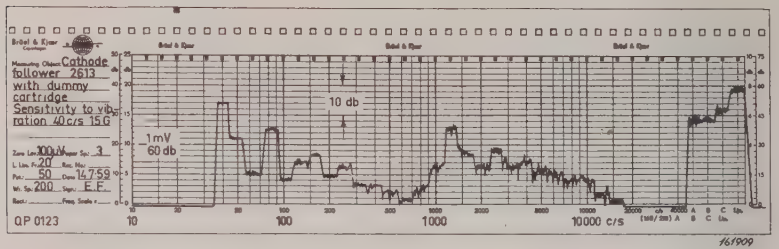


Fig. 1.32. 1/3 Octave Spectrogram of the output from a cathode follower which is subjected to vibrations (40 Hz) perpendicular to its axis.

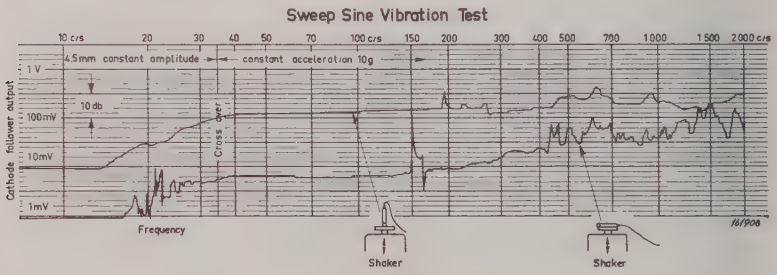


Fig. 1.33. Output from a cathode follower and microphone subjected to a frequency sweep vibration test.

13. Influence of Humidity.

Large variations of ambient temperature may in some cases cause moisture condensation to take place between the diaphragm and the electrode of the cartridges. There is then a temporary risk of electrical noise and cracking. However, due to the heat generated by the cathode-follower, the condensed water will evaporate within a few minutes through the pressure equalization tube. A complete description of these phenomena will be found in the B & K Technical Review No. 1-1960, p. 12—15.

When the Silica Gel Cap UA 0135 is used as described on p. 11 no condensation will take place and the relative humidity percentage of the atmosphere has practically no influence on the microphone sensitivity. The one-inch microphones are not designed for permanent exposure outdoors. A rain cover (Type UA 0056) has been designed for this purpose for the half-inch microphone Type 4133 + 2615.

2. Accessories

Random Incidence Corrector UA 0055.

Many noise level measurements involve sound waves impinging on the microphone with variable or undefined incidence, e.g. noise from aircraft in flight, noise in workshops, etc. In addition, the spectral composition often varies with incidence.

A realistic analysis of the sound pressure is in such cases only possible by means of an omnidirectional and linear microphone, i.e. a microphone presenting a sensitivity which is independent both of the incidence and of the frequency in the measuring range.

It has been noticed (Fig. 1.14) that the sensitivity of the one-inch microphones varies appreciably as a function of the incidence above 3—4 kHz. The normal incidence sensitivity is in particular well above the random incidence sensitivity (e.g. 6 dB greater at 10 kHz).

This is a certain source of error when, for example, measuring the sound produced by a machine-tool in a workshop since the reflected sound is attenuated at high frequencies with respect to the direct sound in the measurement.

Fig. 2.1. The Random Incidence Corrector UA 0055.

The one-inch microphone, however, may be made practically omnidirectional up to 10 kHz by using the Random Incidence Corrector UA 0055 (Fig. 2.1). This specially shaped device, which is designed to be mounted in place of the normal protecting grid of the Cartridge 4131 does not significantly affect the normal incidence response and renders the free-field correction curves of the microphone at incidences other than 0° practically identical to the normal incidence corrections up to 10 kHz Fig. 2.2. The response at any

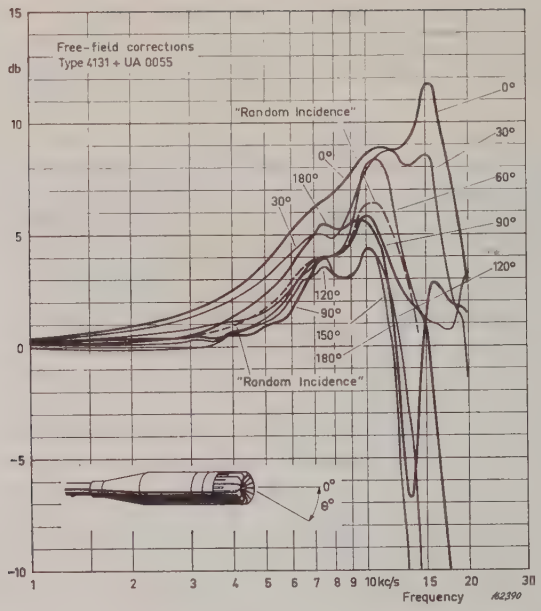


Fig. 2.2. Free-field corrections for the one-inch cartridge (4431 or 4132) with Random Incidence Corrector. Compare with Figs. 1.16 and 1.17.

incidence deviates less than ± 3 dB from the random incidence response up to 10 kHz (Fig. 2.3).

If better omnidirectional properties are wanted, the B & K "Half-inch" (Type 4133/34) or "Quarter-inch" (Type 4135/36) microphone cartridges should be used at the expense of a lower sensitivity.

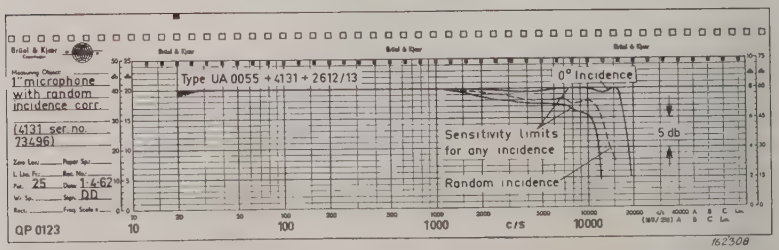
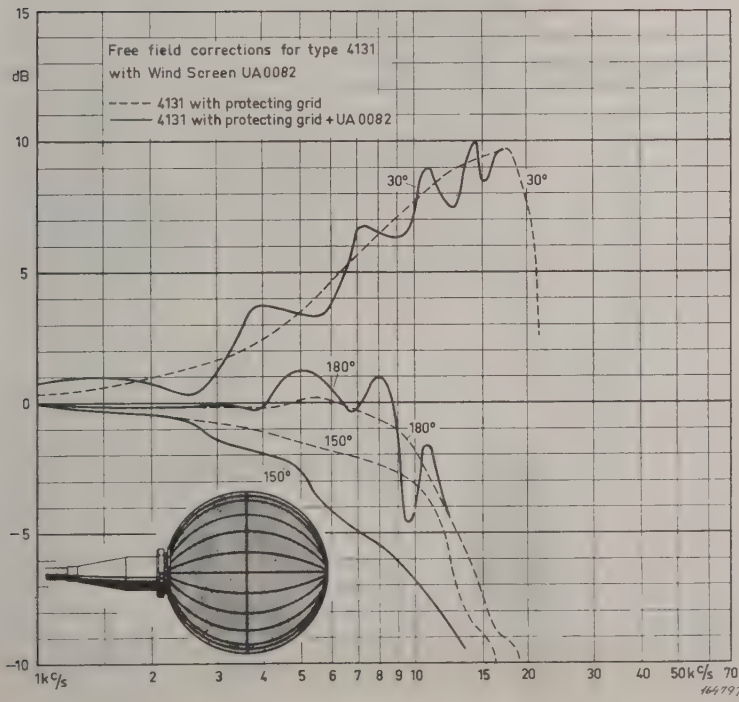


Fig. 2.3. Free-field sensitivity of a one-inch microphone (4131) equipped with the corrector UA 0055. The frequency responses for any incidence (from 0 to 360°) is between the two limiting curves.

Wind Screen UA 0082, Nose Cone UA 0051.

The Wind Screen Type UA 0082 is designed for mounting on the Cathode Follower Type 2612/13 - 2614/15 equipped with a one inch or a half inch condenser microphone. It gives an effective reduction of noise at lower wind velocities in out-door measurements. A description of the design and

Fig. 2.4. The Wind Screen UA 0082.



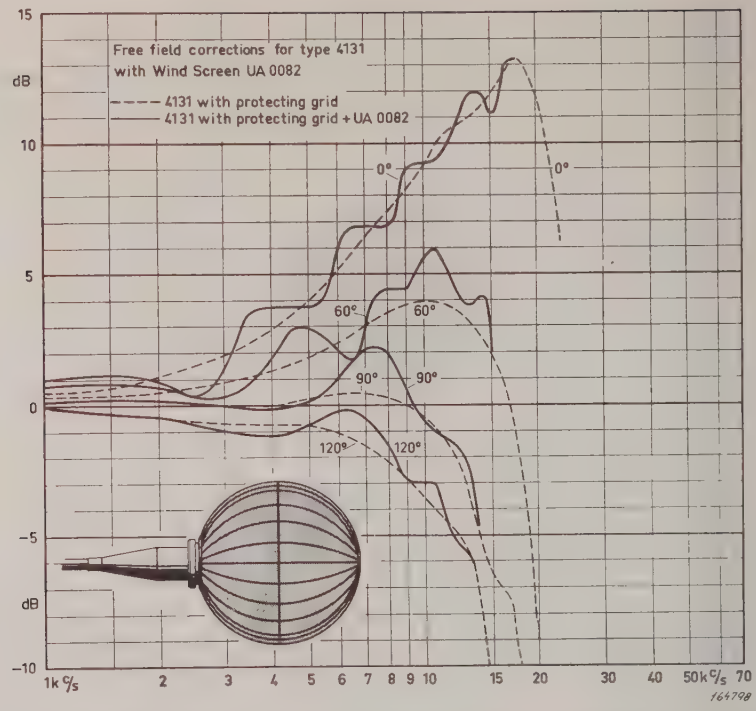


Fig. 2.5. Free field corrections for the total response curve when the Wind Screen UA 0082 is mounted on a Condenser Microphone Type 4131 for different angles of incidence.

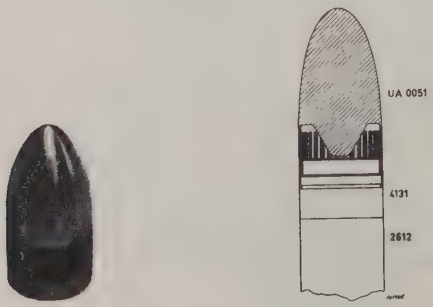


Fig. 2.6. Photo of the Nose Cone UA 0051 and Section of the Nose Cone mounted on a Condenser Microphone.

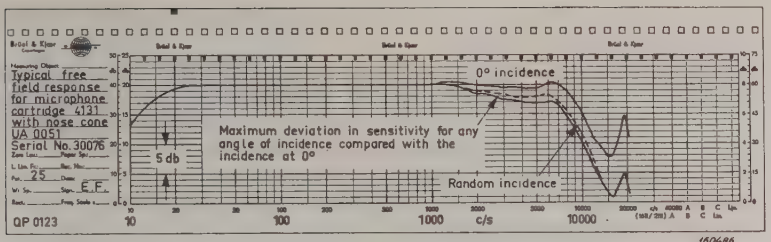


Fig. 2.7. Free field response at 0° incidence, other angles of incidence and random incidence for Microphone Type 4131 fitted with Nose Cone UA 0051.

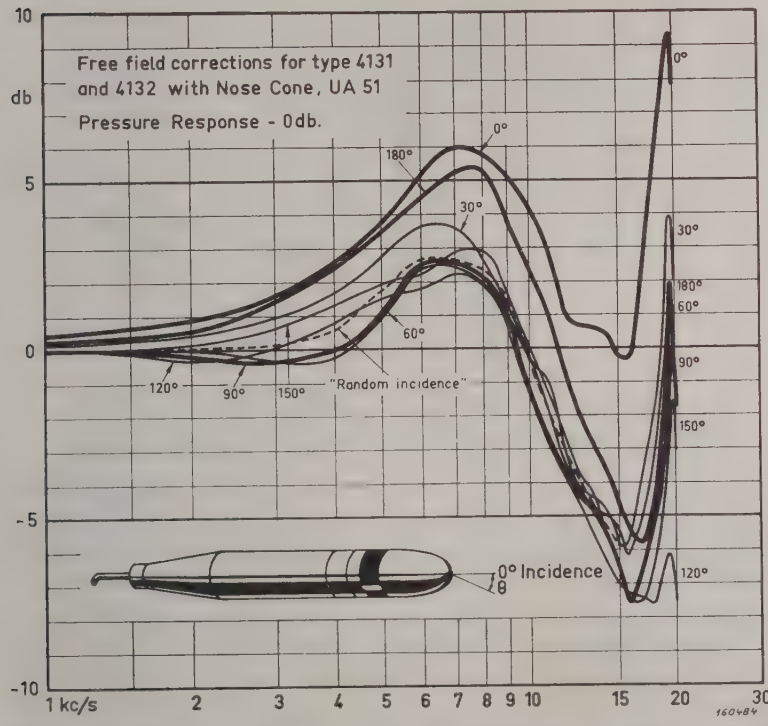


Fig. 2.8. Free field corrections for the total response curve when the Nose Cone UA 0051 is mounted on a Condenser Microphone 4131 or 4132, for different angles of incidence.

characteristics of Wind Screens and Nose Cones will be found in the B & K Technical Review No. 2-1960.

The Nose Cone UA 0051 is designed to substitute the protection grid of the Microphone Type 4131. The Nose Cone is extremely useful for measurements in wind tunnels, ducts and in other locations where the microphone is subjected to high speed airflows as well as for many out-of-door applications, where wind disturbance is likely to occur. In addition, a microphone, when used with the Nose Cone, has omnidirectional properties which are often of advantage. See Figs. 2.7, 2.8 and 2.9.

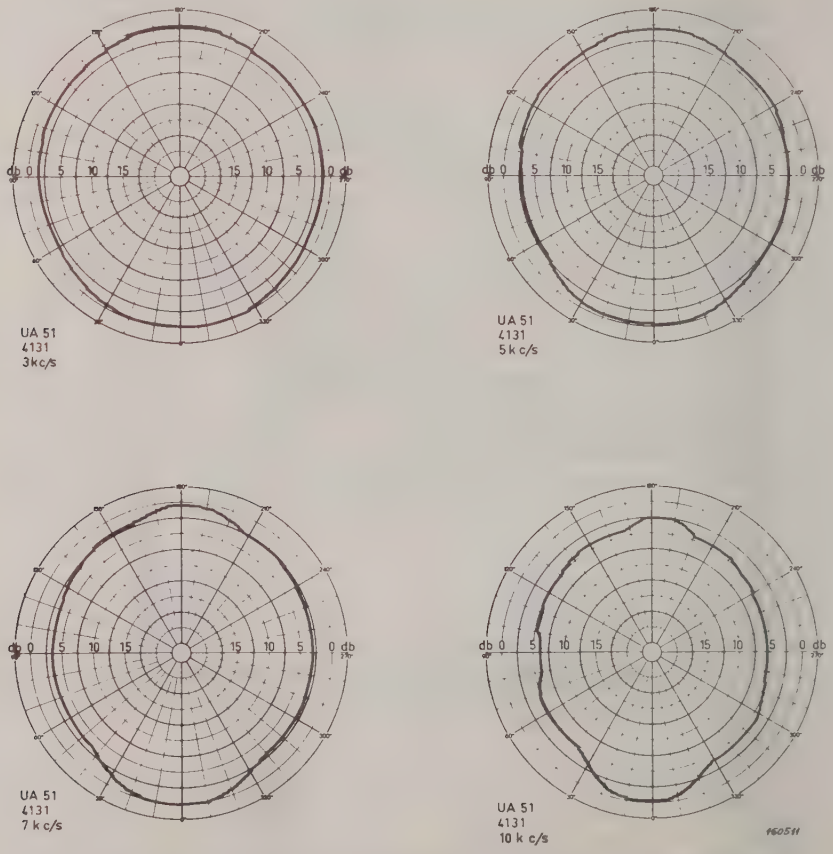


Fig. 2.9. Directional patterns of the condenser microphone Type 4131 equipped with a nose cone UA 0051 instead of the protecting grid.

Microphone Stand UA 0049.

This stand fitting all types of B & K microphones will be of invaluable assistance in field measurements, where the microphone should always be placed in an undisturbed region of the sound field, i.e. in most cases apart from the instruments.

It is a lightweight portable tripod with telescopic legs, similar to those used in photographic work, as shown in Fig. 2.10. The height of the Stand can be adjusted from approximately 50 cm to 140 cm. The Tripod Adapter UA 0028 (seen on top of UA 0049) may be used separately for adapting the microphones on standard camera tripods with thread 3/8" W.

Fig. 2.10. The Microphone Stand UA 0049.

Extension Cables.

When it is desired to use the microphones well apart from the associated instruments an extension cable must be used to make the connection. Several standard lengths of extension cables are available for this purpose.

Extension Cable AO 0027 is a 3 m long multi-core shielded cable supplied with B & K microphone connectors in both ends. The diameter is 6 mm.

The capacity of the signal conductor to ground is approximately 100 pF/m (33 pF/foot).

Each conductor is insulated with polyethylene and the outside of the cable has a grey P.V.C. covering. The cable is specially designed for low leakage between the cores.

Extension Cable AO 0028 is a 10 m long multi-cored shielded cable, supplied with a co-axial signal conductor and B & K microphone connectors at both ends. The diameter is 9 mm. The cable is specially designed to give low microphony, excellent shielding of the signal core and low leakage between the cores enable long runs of cables to be used.
The capacity of the co-axial signal conductor to ground is approximately 57 pF/m (19 pF/foot). It is possible to use cable lengths of up to 200 m, see Fig. 1.11. If larger cable lengths are to be used, the filament series resistor, included in the normal B & K microphone amplifier, should be adjusted so that the filament voltage on the cathode follower tube is 6.3 volts. The conductors are polyethylene insulated and the cable is covered with a grey P.V.C. covering.

Extension Cable AO 0029, as for AO 0028, but 30 m long.

Tape Microphone Cable AR 0001. This very flexible, flat 7-cored microphone cable is used when sound insulation and reverberation measurements are made in buildings and where it is necessary to carry a microphone cable through closed windows and doors. The flat cable can easily follow sharp bends, the thickness of the cable being 0.2 mm. Cable length around 30 cm (1 ft.).

Adapter UA 0030. This adapter is designed to enable the use of a One-Inch Cathode Follower Type 2612/13 or 2630 in connection with a Half-Inch Microphone Cartridge Type 4133, 4134. The adapter extends the "guard ring" system of the cathode follower. Total length 121 mm.

Note: The low-frequency cut-off of the combination 4133/34 — 2612/13 is around 25—30 Hz.

Fig. 2.11. Adapter UA 0030.

Flexible Extension Rod UA 0039.

This adaptor introduces a flexible goose-neck between a one-inch cathode follower (Type 2612/13 or 2630) and the microphone cartridge. It is designed for use with ambient temperatures up to 150°C, and it accepts both the

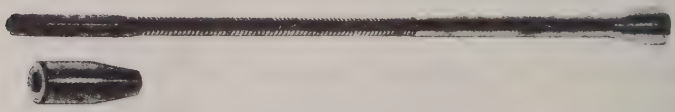


Fig. 2.12. Flexible Extension Rod UA 0039.

one-inch and the half-inch cartridges on the input end. It extends the "guard ring" system of the cathode follower in the same manner as UA 0030. Input impedance of 2612/13 or 2630 + UA 0039: 270 MΩ paralleled by 6 pF. Total length: 46 cm (1½ foot). See Fig. 2.12.

Acoustic Couplers.

Various couplers are in serial production in connection with the B & K Artificial Ear and Microphone Calibration Apparatus in accordance with the American Standards. The following couplers are designed for use with the Microphone Type 4132 (the nominal volumes include the nominal equivalent volume of the cartridge, i.e. 0.15 cm^3).

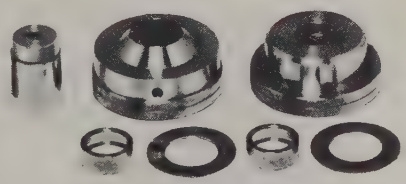


Fig. 2.13. Left to right: Couplers DB 0138, DB 0160 and DB 0161.

The Acoustic Coupler Type DB 0138 is a coupler of 2 cm^3 for measurements on insert type earphones and fulfills the ASA and IEC Standards. It is included as a standard fitment to the Artificial Ear Type 4152.
The DB 0160 is a 6 cm^3 coupler for acoustical measurements on earphones and fulfills the requirements for the NBS Type 9A-Coupler.
The DB 0160 includes: 1 NBS coupler, 1 Coupler Adapter DB 0111, and 1 Stop collar for mounting the coupler on the one-inch microphones.
The Coupler DB 0161 is a 6 cm^3 coupler similar to DB 0160 but is designed to fulfill the requirements of the American Standard ASA Z 24.9 1949 for Type 1 coupler. It is mounted in the same manner as the DB 0160.
Further information about the couplers will be found in the B & K Technical Review No. 4 - 1961.

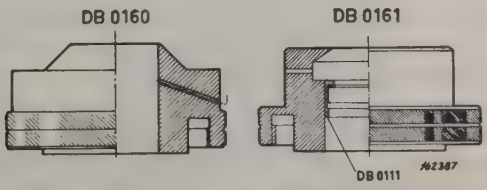


Fig. 2.14. Sectional view of the 6 cm^3 couplers.

Note: If no special precautions are taken the gas contained in the coupler also fills the microphone cartridge. If the gas density differs markedly from that of air at atmospheric pressure, a change in damping and in frequency response is to be expected.

The Two Channel Microphone Selector Type 4408.

The Two Channel Microphone Selector Type 4408 is designed especially for use with B & K condenser microphones and enables the output from one or the other of two microphones to be alternately switched to the input of a single amplifier. (The B & K instruments Types 2603/4, 2107, 2112, 2211, 2212, 2801 are able to power two microphones from a single CONDENSER MICROPHONE input socket).

A recording of two phenomena, e.g. the sound pressure at two different points in a sound field, can thus be obtained on a level recorder.

The microphone selector is mounted in a metal case as shown in Fig. 2.15, and contains a toggle switch for manual operation of a relay, which selects one or other of the microphone inputs. The relay is powered from the microphone power supply.

The selector may also be remotely controlled. The toggle switch is then switched to position "2", and an external control switch connected to the terminals marked EXTERNAL CONTROL. The external switch then replaces the function of the toggle switch.

Fig. 2.15. The Two Channel Microphone Selector Type 4408.

NB: The filament voltage supply wiring in the 4408 provides for series connection of the cathode follower filaments and one cathode follower cannot, therefore, be used singly with this instrument.

Microphone Power Supply Type 2801.

The Microphone Power Supply is for example used in conjunction with tape recording of measurement data in the field in cases where B & K Amplifiers or Analyzers are not available, or where extremely long extension

cables must be used between the microphone and the succeeding amplifier. The power supply unit supplies the necessary filament, anode and polarization voltage for the microphones, and, in addition, it contains a transformer stage to convert the output impedance of the cathode follower into impedances of 50 ohms, 200 ohms and 200 ohms symmetrical.

The power supply unit is heavily stabilized for variations in mains voltage and may be operated from power outlets with 100—115—127—150—220 or 240 Volts (50 to 400 Hz).

The Microphone Power Supply can also be employed in conjunction with the above mentioned Microphone Selector Type 4408. For further details the reader is referred to the separate instruction manual for Type 2801.

Fig. 2.16. The Microphone Power Supply Type 2801.

Two-Channel Power Supply Type 2803.

The Two-Channel Power Supply Type 2803 features the advantages of both Type 4408 and Type 2801 being equipped with power supply for two cathode followers, two inputs and two outputs and EXTERNAL CONTROL socket for external control of switching between the two inputs.

Furthermore the two channels can be operated separately, each channel consists of a 0—40 dB continuously variable attenuator succeeded by an emitter follower, which converts the relatively high output impedance of the

Fig. 2.17. The Two-Channel Power Supply Type 2803.

cathode follower to a much lower impedance of 15 ohms in series with 5 μF. By means of the FUNCTION SELECTOR it is possible to obtain 5 different combinations of the two inputs and the two outputs. One of these combinations is performed by a built-in automatic channel selector which connects the two input signals alternately to one output at a recurrent frequency of approximately 0.5 Hz. The three power supplies for the cathode follower voltages are stabilized in order to be insensitive to variations in the mains voltage and the polarization voltage is made adjustable from 190—210 volts DC. For further information see instruction manual for Type 2803.

Cathode Follower Type 2617.

The Cathode Follower Type 2617 has been designed especially to allow calibration of the B & K Condenser Microphone Cartridges Type 4131/32 according to the "insert voltage" method. Therefore the thread for the cartridges is isolated from the cathode follower housing (ground).

With the Type 2617 Cathode Follower connected to the Insert Voltage Junction Box ZH 0007 it is possible to measure the "open circuit voltage" of the microphone as specified in the American Standards Z 24.4-1949 and Z 24.11-1954 and the proposed American Standard September 1963. (See page 53).

When the cathode follower is plugged directly into a B & K instrument having a CONDENSER MICROPHONE input the microphone cartridge is grounded automatically.

The shield around the input contact can be connected either to the cathode or to ground by means of a switch situated on the print inside the housing. This has been so designed in order to satisfy both the demand of a grounded shield (ASA Z 24.4-1949 and Z 24.11-1954) and the possibility of using a "driven" shield as mentioned in the proposal for revision (Sept. 1963) of the ASA Standard.

In the proposal a "driven" shield is allowed as long as the open-circuit voltage measured is constant to within 0.02 dB when the shield is switched from "driven" to "grounded". It can thus be decided by the user whether to work with the shield connected to cathode ("driven") or to ground.

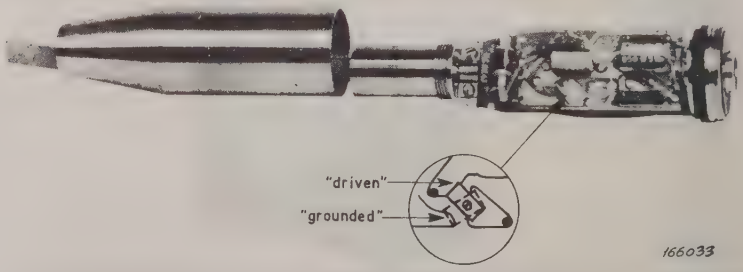


Fig. 2.18. Exploded view of the Cathode Follower Type 2617 showing the switch for the input shield (driven or grounded).

SPECIFICATIONS:
Input resistance: 1300 MΩ.
Input capacity: driven shield: 3.5 pF, grounded shield: 4.6 pF.
Lower limiting frequency (—1 dB): 4.5 Hz (generator: 60 pF).
Output impedance: < 700 Ω.
Voltage attenuation: 0.8 dB ± 0.15 dB.
Inherent noise: lin. 20—35000 Hz < 20 μV.
1/3 oct. 50 Hz < 5 μV.
Frequency range (—1 dB): 4.5—200000 Hz.
Distortion: 0.1 volt input: < 0.1 %.
10 volt input: 1.3 %.

Battery-driven Cathode Follower Type 2630.
The Cathode Follower Type 2630 is designed in accordance with the same principles as the Cathode Followers Type 2612 and 2613, but includes in its housing a transistorized power supply delivering the necessary polarization, plate and filament voltages from three small mercury cells. The external diameter of the housing varies from 23.77 mm (0.936″) to 25.4 mm (1″) and

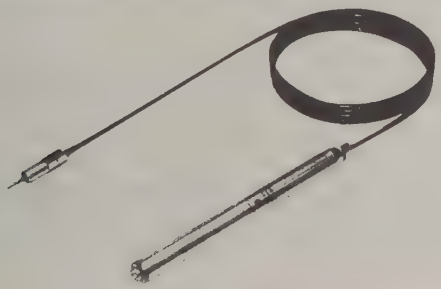


Fig. 2.19. The battery driven Cathode Follower Type 2630.

its total length is 27 cm (11″). A small moving coil voltmeter is also included for checking the batteries' output voltage. The 2630 is equipped with a 3 m (10 ft) long cable at its output. It is delivered with 3 Mallory RM.1-R cells (continuous service life around 20 hours) and an input adaptor for connection of accelerometers etc.
A typical utilization of the battery-driven cathode follower is for the recording in the field of noise or other fluctuating sound pressures by means of transistorized tape recorders, enabling frequency- and statistical analyses to be carried out later in the laboratory.

SPECIFICATIONS:
Input Impedance: 270 MΩ paralleled by 3 pF.
Output Impedance: less than 300 Ω. See also Fig. 2.20.

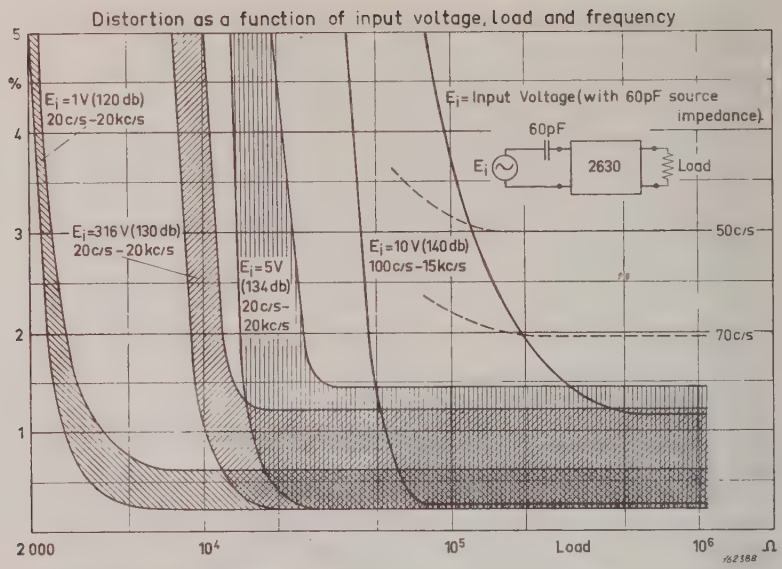


Fig. 2.20. Diagram showing the 2630's distortion as a function of the load impedance in different conditions. Only the limits of the region containing all the curves for discrete frequencies are given.

Example of application: Distortion introduced by the 2630 for an input voltage of up to 1 V (120 dB SL with Microphone Cartridge Type 4131) is smaller than 1 % in the range 20 Hz—20 kHz if the load impedance is higher than 4 kΩ. With 10 V input voltage (140 dB SL with Microphone Cartridge Type 4131) the distortion is less than 2 % only in the frequency range 70 Hz—15 kHz and if the load impedance is higher than 200 kΩ.

Gain: — *o.8 dB* ± *o.2 dB.*

Frequency Linearity: ± o.2 dB from 30 Hz to 20 kHz, and with 50 pF at input ± 1 dB from 20 Hz to 200 kHz. With 500 pF at input (e.g. an accelerometer), the response falls 1 dB at 3 Hz and 3 dB at 2 Hz.

Total Noise Level (with 50 pF at the input) in the range 20 Hz—35 kHz: less than 35 μV (decreases when the battery voltage decreases).

Microphonics: the signal-to-noise ratio is higher than 50 dB at 130 dB SL when used with a microphone cartridge having a sensitivity of 5 mV/μbar.

Rise Time and Fall Time: about o 3 and 1 μsec. respectively.

Distortion: less than 4 % up to 200 kHz with input voltage o.1 Volt and loaded by 1.1 MΩ//30 pF (Type 2604). See also Figs. 2.20 and 2.21.

Temperature Influence: less than ± o.4 dB in the range — 5° C to + 60° C (+ 23 to 140°F).

Storing temperature range: — 10 to + 72°C.

Batteries: 3 Mallory cells type RM1 or RM1-R. B & K part number: QB 0007.
Service life (with 8 hours service periods): 20 hours.

***Weight* with batteries and 3 meters cable: o.6 kg.**

Tube: CK 512 AX; *Transistors:* 2 × 2N2374.

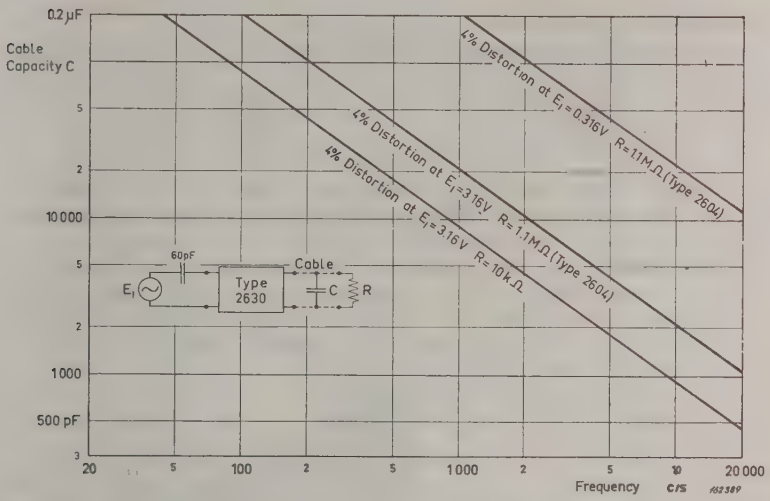


Fig. 2.21. Limitation of the frequency range when using long cables (3.16 V is equivalent to 130 dB SL when using a 4131 microphone cartridge at the input). The B & K standard screened cable AC 0002 presents a capacity of 100 pF/m.

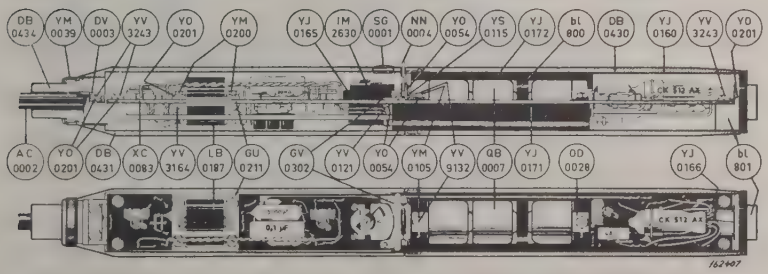


Fig. 2.22. Part Numbers of the battery-driven cathode-follower. The batteries are accessible by screwing DB 0430 off and removing YJ 0172. (YJ 0160 has to be pulled a little).

Appendix

Microphone Calibration.

Determination of the Error in an Absolute Sound Level Measurement.

Considering the various standard*) errors a, b, c --- which are expected to occur on each of all the different parts of the measuring arrangement, the total standard error is

$$S = \sqrt{a^2 + b^2 + c^2 + \text{----}}$$

In the case of the measuring arrangement of Fig. 1.2, for example, the different errors to be considered in the measurement of the sound pressure level on the microphone diaphragm are as follows (rough estimation):

(a) Microphone cartridge calibration: o.2 dB after proper corrections.
(b) Transmission loss of the cathode follower and loading of the cartridge: o.1 dB.
(c) Polarization voltage's deviation from 200 V: o.2 dB.
(d) Voltage calibration of the 2603: o.1 dB.
(e) Meter scale and attenuators: o.2 dB.
(f) Reading error: o.1 dB.
(g) Uncertainty on the frequency response of the measuring equipment, which should be taken into account when considering bands of noise having frequencies differing greatly from the frequency of microphone calibration (250 Hz). Still considering the equipment of Fig. 1.2, this uncertainty is about ±o.1 dB from 50 Hz to 1 kHz, and ±o.5 dB from 30 Hz to 10 kHz for a free-field measurement at 0° incidence with the 4131. When measuring broad band noise through the A-B-C weighting networks of the 2603 the probable frequency response uncertainty is of the order of ±o.5 dB.

Equating o.1 dB to 1.1 %, o.2 dB to 2.2 % and o.5 dB to 6.0 %, the standard error in the measured result will thus be

$$S = \sqrt{2.2^2 + 1.1^2 + 2.2^2 + 1.1^2 + 2.2^2 + 1.1^2 + 6.0^2} = \pm 7.7\ \% = \pm o.64\ \text{dB}$$

Note: In some cases of irregular statistical distribution of signal amplitudes, errors may be caused by the limited averaging time (damping) of the meter or by the limitation of the RMS rectifier possibilities.

If a better accuracy is desired, the most practical and reliable solution is to make a direct calibration of the whole measuring arrangement before each series of measurement by means of a calibrated sound source. Then the errors

*) The standard error s is such that there is 68 % chance of obtaining errors smaller than s, 90 % smaller than 1.65 s. and 99 % smaller than 2.58 s.

(a) (b) (c) (d) outlined above are replaced by the source calibration error and the calibration reading error. When using a Pistonphone Type 4220, these errors may be estimated each to 0.1 dB. The total standard error is then reduced to S = 0.55 dB (0.27 dB for pure tones for which error (g) may be eliminated).

Microphone Calibration Equipment.

The **Pistonphone Type 4220** produces, when fitted to a B & K microphone, a sound pressure level of 124 dB at 250 Hz which is known with an error of less than ± 0.2 dB. This enables a direct calibration in dB SL of the scale to be read, and measurements therefore to be taken with an excellent accuracy if the frequency response and the dynamic linearity (including the attenuators) of the instrumentation following the microphone are ascertained. The Pistonphone Type 4220 (Fig. A.1) is a small, portable battery-driven unit weighing only 0.7 kg which is extremely well-suited for field calibration. A barometer is supplied with the instrument for direct reading of ambient pressure corrections, together with various adaptors for fitting to the different B & K microphones. For further information see instruction manual for Type 4220.

A higher accuracy can be obtained by means of the reciprocity method when corrections are made for cathode follower attenuation (see open-circuit

Fig. A.1. The Pistonphone Type 4220 in case with barometer and coupler adaptors for B & K microphones.

voltage technique below), ambient pressure (can also be made when using the pistonphone), coupler heat-conduction and variations in equivalent volume of the microphone.

Calibration by means of the **Microphone Calibration Apparatus Type 4142** utilizing the reciprocity technique, which is the method retained by the American Standard Association (Z 24.4.1949), is relatively time-consuming and is employed mainly for calibration of standard microphones.

The Microphone Calibration Apparatus Type 4142 provides all the accessories which are needed for carrying out the reciprocity calibration of the B & K microphones in combination with a Beat Frequency Oscillator Type 1022 and a Microphone Amplifier Type 2603. (See the measuring set-up Fig. A.2). Three different coupler volumes are available: 20, 3, and 0.3 cm^3 usable up to 20 kHz (60 kHz when hydrogen filled). In addition, Type 4142 includes two Electrostatic Actuators (Types UA 0023 and UA 0033) for frequency response calibration of 1″ and 1/2″ microphones and provides the necessary 800 V polarization voltage. This is the method employed in the production tests made at Brüel & Kjær. Finally the Microphone Calibration Apparatus allows the open-circuit voltage sensitivity of the cartridges to be measured.

The "one-inch" **Electrostatic Actuator Type UA 0023** (Fig. A.3) may be used separately when only the frequency response is to be investigated. The

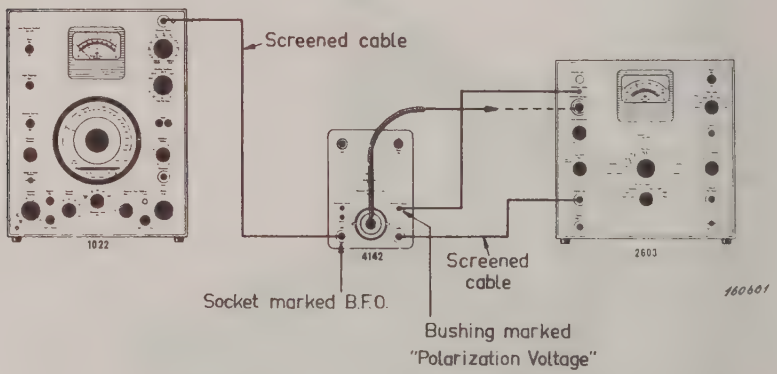


Fig. A.2. Measuring set-up for the reciprocity calibration of a B & K microphone.

actuator is placed on the microphone cartridge held vertically. It has three glass studs which contact the periphery of the cartridge diaphragm in order to obtain an accurate definition of the spacing between actuator grid and diaphragm. By applying an AC voltage between the grid and the diaphragm a fictive sound pressure proportional to the square of the voltage (at double frequency) is obtained. When using a BFO Type 1022 the maximum available

voltage of 120 V will provide an equivalent sound pressure level of about 80 dB which remains constant within ± o.6 dB from 40 Hz to 40 kHz. Better accuracy (± o.3 dB) and higher sound level without frequency doubling may be obtained by using the constant DC bias provided by the 4142.

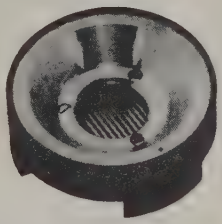


Fig. A.3. The Electrostatic Actuator UA 0023.

Since the fictive pressure is not affected by ambient conditions, the actuator is an excellent means for the determination of the variations in microphone sensitivity under changing environments.

Also the B & K **Noise Source Type 4240** should be mentioned. The Noise Source is a small mechanical-acoustical device producing a well defined sound pressure with continuous spectrum and practically gaussian amplitude distribution. It provides a quick and reliable field calibration check of sound level meters with all the advantages of the "white noise" testing. Each Noise Source is individually calibrated, the nominal sound level produced being 108 ± 1.5 dB. The last-named calibration methods are thoroughly described in the instruction manuals for Types 4142 and 4240.

Open-Circuit Voltage Determination.

The open-circuit voltage of a microphone at a given single frequency is the voltage which appears at its terminals when the microphone is working into an effectively infinite electrical impedance. It is measured by the substitution method (Insert Voltage Technique): A source of known and adjustable voltage is connected in series with the microphone and an amplifier-indicator system. Sound pressure and calibrating voltage are applied alternately with the microphone diaphragm terminated in the same acoustic impedance. The calibrating voltage is now adjusted until it is the same as the electromotive force generated by a given sound pressure acting on the microphone diaphragm in the absence of the calibrating voltage. The open-circuit voltage is then equal in magnitude to the calibrating voltage.

This measurement is easily carried out when using the **Cathode Follower Type 2617** in connection with the **Insert Voltage Junction Box Type ZH 0007.** The latter can be plugged directly into a Microphone Amplifier Type 2603 or a Spectrometer Type 2112 or any other B & K instrument having a CON-

DENSER MICROPHONE input. As voltage source the Beat Frequency Oscillator Type 1022 may be used. (See Fig. A.4).

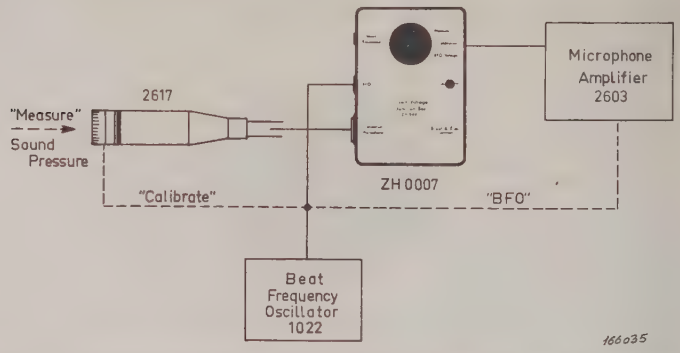


Fig. A.4. Block-diagram showing the use of the Insert Voltage Technique.

The measuring procedure is as follows:

1. With the FUNCTION SELECTOR switch of the ZH 0007 in position "Measure" the output voltage from the cathode follower is indicated while the microphone is exposed to a certain sound pressure.
2. With the sound pressure switched off and the FUNCTION SELECTOR in position "Calibration" the output voltage from the BFO Type 1022 is adjusted so that the indicated output voltage from the cathode follower is the same as above (item 1).
3. The open-circuit voltage is now identical to the output voltage of the BFO. This voltage can be read from the indicating instrument (when calibrated) with the FUNCTION SELECTOR switch of the ZH 0007 in position "BFO Voltage" or from a voltmeter connected to the INSERT RESISTANCE socket.

The difference between the readings under items 2 and 3 at the indicating instrument is caused by the attenuation of the cathode follower and its input circuitry.

Therefore if the sound pressure is known the sensitivity of the microphone can be calculated.

Item 2. Gives the sensitivity of the microphone loaded with the cathode follower and including the attenuation of the cathode follower.

Item 3. Gives the open-circuit sensitivity of the microphone.

An Extension Cable AO 0027 can be used between the Insert Voltage Junction Box ZH 0007 and the indicating instrument (if a Microphone Power Supply Type 2801 is employed it is necessary to use the extension cable). It can also be used between the cathode follower plug and the ZH 0007.

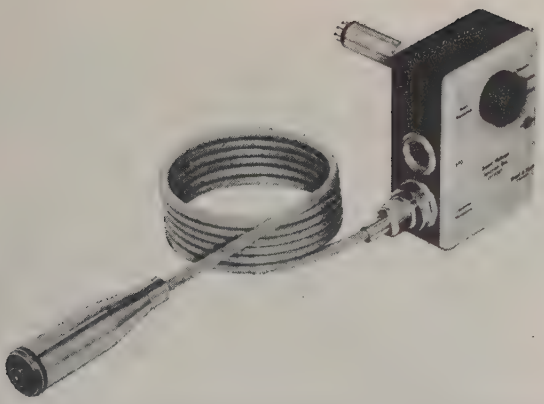


Fig. A.5. The Cathode Follower Type 2617 and the Insert Voltage Junction Box ZH 0007.

Comparison between Type 4132 and Type WE 640 AA.

The characteristics of the B & K Condenser Microphone Type 4132 are very similar to those of the microphone Type WE 640 AA which is often used as laboratory standard. By a simple external modification of the Cartridge Type 4132 the normal incidence free field characteristics of the two microphones can be made identical. This modification which consists of mounting a perforated grid onto the cartridge with interposition of a coupler adaptor DB 0111, is illustrated in Fig. A.6. The resulting change in frequency characteristics is seen in Fig. A.7. The adaptor DB 0111 is included in the Couplers Type DB 0160 and DB 0161 (see Accessories).

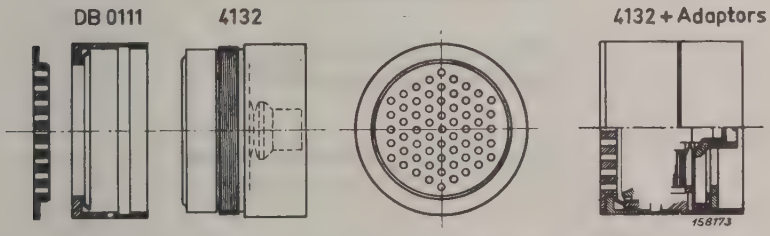


Fig. A.6. Modification of the Cartridge Type 4132 giving the same frequency characteristics as the Type WE 640 AA.

The Range of B & K Condenser Microphones.

Compared characteristics of the different types of condenser microphones made by B & K are summarized in the figures and tables below. They are all of similar construction, but differ in dimensions, the smaller diameters

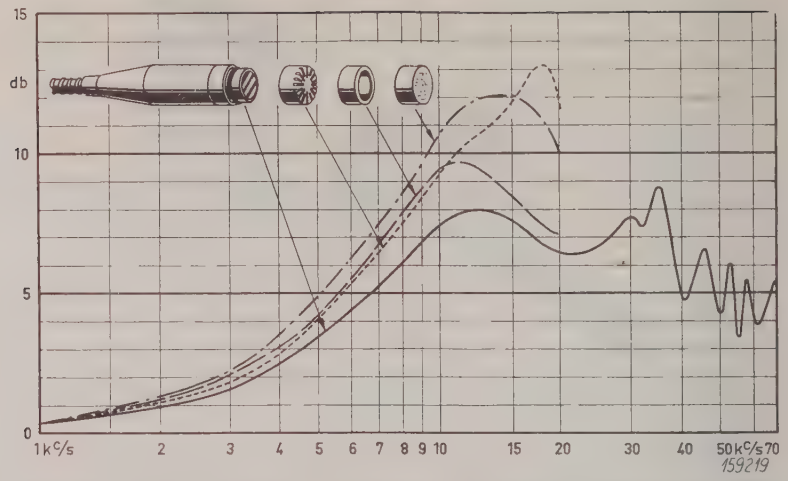


Fig. A.7. Free field correction curves for the Microphone Cartridge Type 4132:

1) Without protecting grid.
2) With normal protecting grid.
3) With adaptor DB 0111.
4) With adaptor + perforated grid.

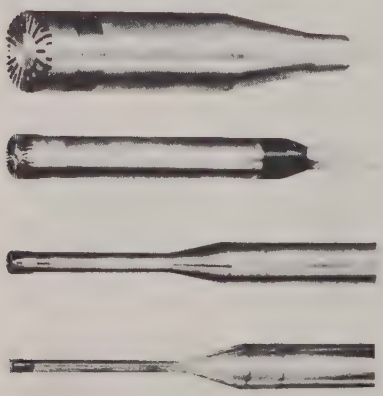


Fig. A.8. From top to bottom:

Type 4131/32 + 2613 (23.77 mm outside diameter)
Type 4133/34 + 2615 (12.7 mm outside diameter)
Type 4135/36 + UA 0035 + 2615 (6.35 mm outside diameter)
Type 4138 + UA 0036 + 2615 (3.175 mm outside diameter)

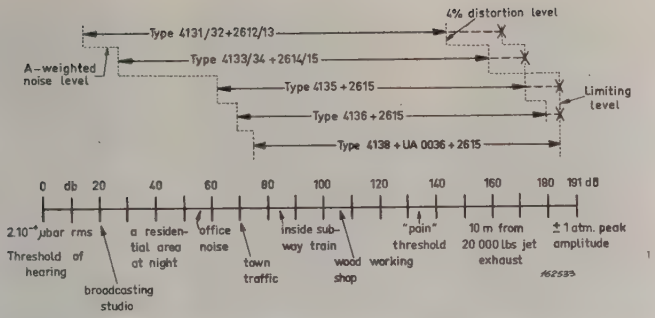


Fig. A.9. Compared dynamic ranges of the B & K condenser microphones.

giving higher limits of the frequency and dynamic range at the expense of a lower sensitivity.

For detailed description, the reader is referred to the respective Instruction Manuals. However a rough estimation of the general characteristics of all types may be obtained by extrapolation of the characteristics described in this manual for the half-inch microphones.

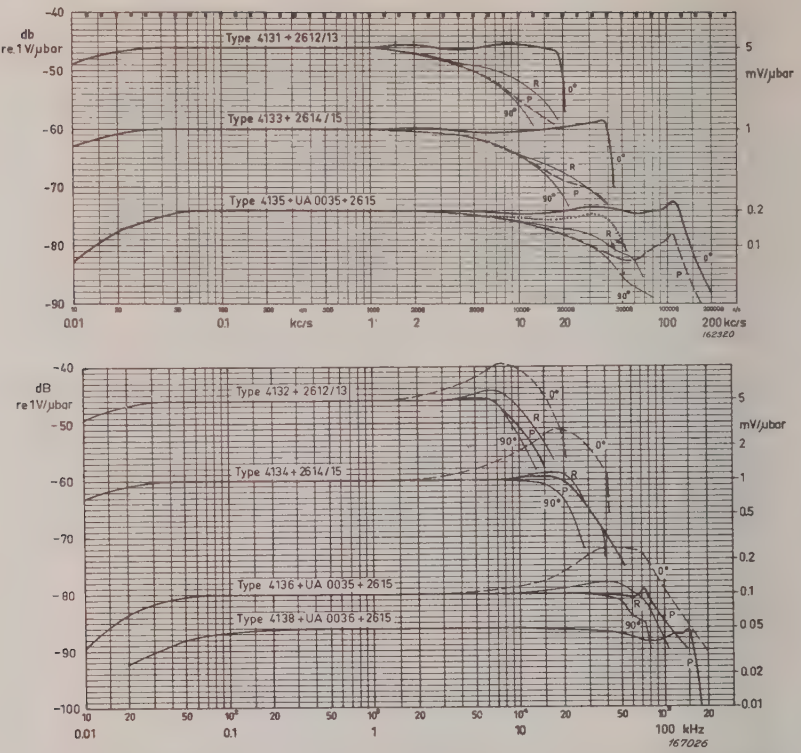


Fig. A.10. Frequency response of the different B & K condenser microphones (without accessories).

0° = free-field response at 0° (normal incidence).
90° = free-field response at 90° (grazing incidence).
R = random incidence response (diffuse field).
P = pressure response (towards higher frequencies, the slope is about — 12 dB/octave).

NB. Valid with protecting grid for types 4131—34 (1" and ½") and without protecting grid for types 4135—36 (¼") and 4138 (⅛") with exception of the dotted "R-curve" of 4135 which is with grid.

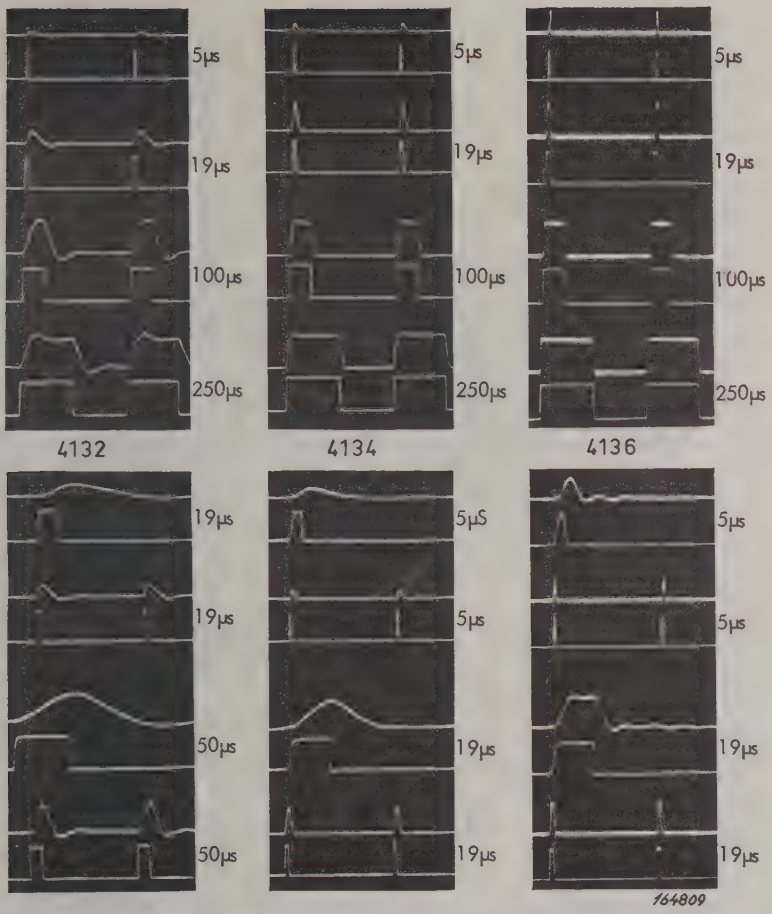


Fig. A.11. Compared pulse-response of the B & K microphones.
From left to right: 1" (4132), ½" (4134) and ¼" (4136).
The microphone is actuated electrostatically by positive rectangular pulses at a pulse recurrence frequency of 2000 Hz with different crest factors (peak amplitude/rms value). Input pulses are represented under the corresponding output pulses.
Above, from top to bottom: crest factors of 10, 5, 2 and 1. (Pulse duration: 5, 19, 100 and 250 µs).
Below: enlarged pulse pictures with horizontal scanning velocity multiplied by 5 for the 4132 and 10 for 4134 and 4136. Unenlarged pictures are represented under the corresponding enlarged pictures. Crest factors 3 and 5 for the 4132 and 5 and 10 for 4134-4136 are enlarged and show that the condenser microphones have practically no ringing.

Survey of the Catalogue-listed Accessories available for each Microphone Series (1", 1/2", 1/4", 1/8" diameter)

Description		1" Type	1/2" Type	1/4" Type	1/8" Type
Microphone Cartridge		4131-32	4133-34	4135-36	4138
Cathode Follower	goose-neck type with 2 m long cable	2612	2614	2614[1]	2614[7]
	with Junction Box ZH 0007	2613	2615	2615[2]	2615[7]
	battery driven	2617 2630	2630[3]		
Front Covers	Random incidence corrector	UA 0055			
	Wind screen	UA 0082	UA 0082		
	Nose cone	UA 0051	UA 0052	UA 0053	
	Rain cover		UA 0056		
	Probe microphone kit		UA 0040	UA 0040[4]	UA 0040[8]
Mountings	Flexible Adaptor (for side-mounting)		UA 0122	UA 0122	
	Flexible Aadaptor (for end-mounting		UA 0123	UA 0123	
	Extension Connector (fitting 2612-13-30)	UA 0039	UA 0039		
Calibration	Electrostatic actuator	UA 0023	UA 0033	UA 0033[4]	UA 0033[8]
	Pistonphone	4220			
	Reciprocity calibration Apparatus	4142			
Acoustical Couplers	Artificial mouth	4152	4216		
	Artificial ear	DB 0160	4152[5]		
	6 cm³ ASA-Z 24.5.1951	DB 0161	DB 0160[5]		
	6 cm³ ASA-Z 24.9.1949	DB 0138	DB 0161[5]		
	2 cm³ IEC 126-1961	DB 0111	DB 0138[5]		
	Coupler adapting ring		DB 0111[5]		
Cartridge extension cable (3 m, for use with 2203)		AO 0033			
Extension cables (3 m - 10 m - 30 m) Tape microphone cable (o.3 m)		AO 0027-28-29 AR 0001			
Microphone stand		UA 0049			
Microphone power supply		2801			
Two-channel power supply		2803			
Two-channel microphone selector		4408			
Sound measuring equipment[6]	Portable sound level meter	2203	2203[3]		
	Portable octave filter set	1613			
	Sound level meter	2603 - 2604			
	Spectrometer (1/1 and 1/3 octave)	2112 - 2211 - 2212			
	Frequency analyzer	2107			

1) Add Adaptor UA 0035.
2) Add Adaptor UA 0035.
3) Add Adaptor UA 0030 or UA 0039 or AO 0033.
4) Add 1/4"—1/8" Adaptor DB 0264.
5) Add 1/8"—1" Adaptor DB 0225.
6) Following the recommendations of the IEC for Precision Sound Level Meters.
7) Add Adaptor UA 0036.
8) Add Adaptor DB 0900.

COMPARATIVE SPECIFICATIONS

Type	4131 + 2612/13	4132 +2612/13	4133 +2614/15	4134 +2614/15	4135 + UA 0035 + 2615	4136 + UA 0035 + 2615	4138 + UA 0036 + 2615
Nominal Cartridge Diameter	1 inch		½ inch		¼ inch		⅛ inch
Frequency Response*) See Fig. 3. Flat within ± 2 dB in the range:	**Free-field** (0° incidence) 20 Hz to 18 kHz	**Pressure** 20 Hz to 7 kHz	**Free-field** (0° incidence) 20 Hz to 40 kHz	**Random incidence and Pressure** 20 Hz to 20 kHz	**Free field** (0° incidence) 30 Hz to 100 kHz	**Random incidence and Pressure** 30 Hz to 70 kHz	**Random incidence and Pressure** 30 Hz to 140 kHz
Sensitivity*) at cathode follower output	5 mV/μbar –46 dB re. 1 V/μbar		1 mV/μbar –60 dB re. 1 V/μbar		0.2 mV/μbar –74 dB re. 1 V/μbar	0.1 mV/μbar –80 dB re. 1 V/μbar	50 μV/μbar –86 dB re. 1 V/μbar
Cartridge open-circuit sensitivity*)	–45 dB re. 1 V/μbar		–58 dB re. 1 V/μbar		–70 dB re. 1 V/μbar	–76 dB re. 1 V/μbar	–86 dB re. 1 V/μbar
Dynamic Range (from equivalent A-weighted noise level to 4 % harmonic distortion)	15–146 dB re. 0.0002 μbar		32–160 dB re. 0.0002 μbar		64–174 dB (10 %) re. 0.0002 μbar	70–180 dB (10 %) re. 0.0002 μbar	76–184 dB (10 %) re. 0.0002 μbar
Resonant Frequency (90° phase angle)	10 kHz	8 kHz	25 kHz	25 kHz	75 kHz	75 kHz	
Polarization Voltage	200 V						
Polarized Cartridge Capacity*)	70 pF	60 pF	20 pF		6.4 pF		
Equivalent Air Volume (at 1 atm.)	0.15 cm^3	0.15 cm^3*)	0.01 cm^3	0.01 cm^3*)	0.0005 cm^3		< 0.0001 cm^3
Temperature Range: up to	100°C	100°C	with 2614: 150°C (continuous) 250°C (intermittent) with 2615: 100°C (limited by cable insulator)				
Temperature coefficient between –50°C and +60°C	less than ± 0.01 dB/°C						
Ambient Pressure Coefficient (increase of sensitivity for a 100 mm Hg decrease of pressure)	0.2 dB		0.1 dB		less than 0.1 dB		
Relative humidity influence	less than 0.1 dB (in the absence of condensation)						
Dimensions of cartridge: without protecting grid with protecting grid	diameter / height 23.77 mm (0.936") / 17 mm (0.67") 23.77 mm (0.936") / 19 mm (0.75")		diameter / height 12.7 mm (½") / 11 mm (0.43") 13.2 mm (0.52") / 12.7 mm (½")		diameter / height 6.35 mm (¼") / 9 mm (0.35") 7 mm (0.275") / 10.5 mm (0.41")		diameter / height 3.175 mm (⅛") / 6.0 mm (0.240") 3.50 mm (0.140") / 6.7 mm (0.268")
Thread: grid (or coupler) mounting cathode follower mounting	23.11 mm (0.91") – 60NS2 23.11 mm (0.91") – 60NS2		12.7 mm (0.50") – 60NS2 11.7 mm (0.46") – 60NS2		6.35 mm (0.25") – 60NS2 5.7 mm (0.22") – 60NS2		M 3.175 × 0.2 M 3 × 0.25

*) Individually calibrated.

B & K INSTRUMENTS:

ACOUSTICAL....
Condenser Microphones
Piezo-Electric Microphones
Microphone Preamplifiers
Microphone Calibration Equip.
Sound Level Meters
(general purpose-precision-
and impulse)
Standing Wave Apparatus
Tapping Machines
Noise Limit Indicators

ELECTROACOUSTICAL....
Artificial Ears
Artificial Mouths
Artificial Mastoids
Hearing Aid Test Boxes
Telephone Measuring Equipment
Audiometer Calibrators
Audio Reproduction Test Equip.

STRAIN....
Strain Gauge Apparatus
Multipoint Panels
Automatic Selectors
Balancing Units

VIBRATION....
Accelerometers
Accelerometer Preamplifiers
Accelerometer Calibrators
Vibration Meters
Magnetic Transducers
Capacitive Transducers
Vibration Exciter Controls
Vibration Programmers
Vibration Signal Selectors
Mini-Shakers
Complex Modulus Apparatus
Stroboscopes

GENERATING....
Beat Frequency Oscillators
Random Noise Generators
Sine-Random Generators

MEASURING....
Measuring Amplifiers
Voltmeters
Deviation Bridges
Megohmmeters

ANALYZING....
Band-Pass Filter Sets
Frequency Spectrometers
Frequency Analyzers
Real-Time Analyzers
Slave Filters
Psophometer Filters
Statistical Analyzers

RECORDING....
Level Recorders
(strip-chart and polar)
Frequency Response Tracers
Tape Recorders

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